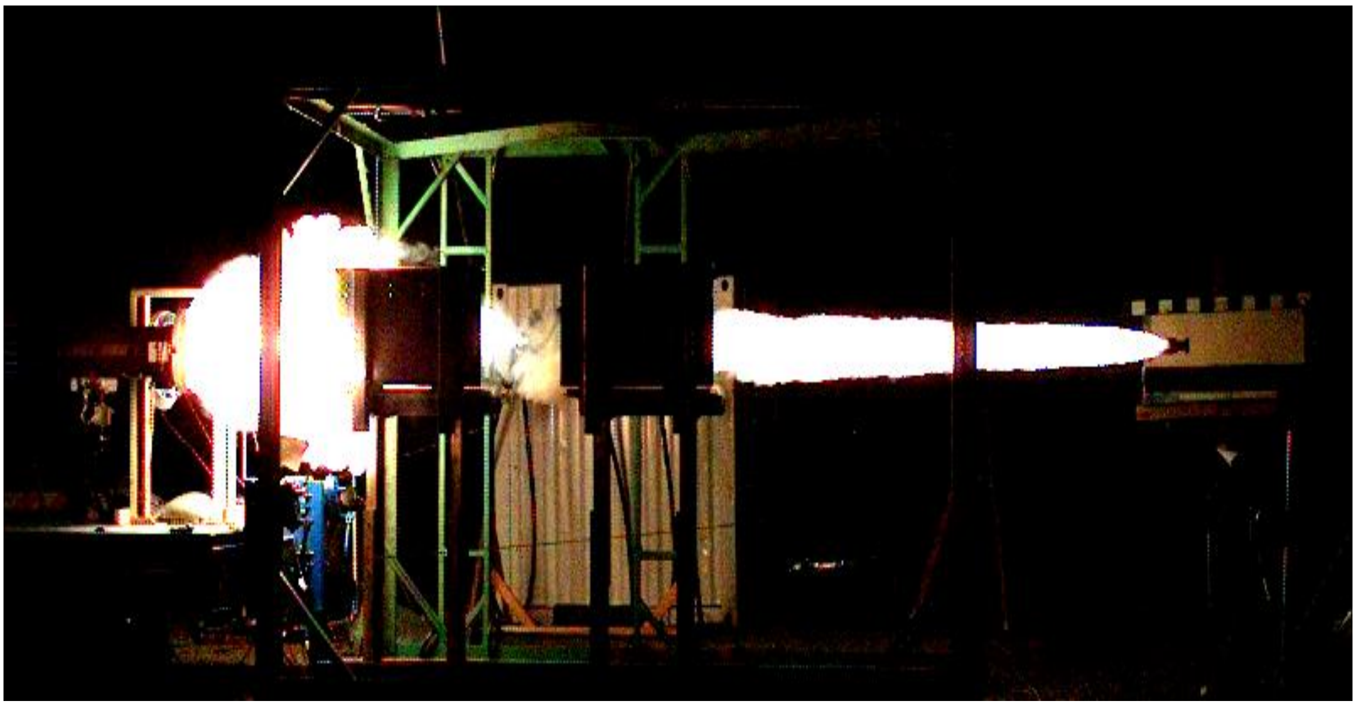
Capabilities Report 2012



West Desert Test Center

DUGWAY PROVING GROUND

SCIENCE SERVING WARFIGHTERS AND CITIZENS

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14. ABSTRACT **U.S. Army Dugway Proving Ground (DPG), West Desert Test Center (WDTC), specializes in planning, conducting, and analyzing results of developmental and production tests. Areas of expertise include chemical and biological (CB) defense systems, smoke and obscurants, materiel and delivery systems, munitions and incendiary devices, meteorological research and modeling, environmental characterization and remediation technology testing, and technology transfer to include specialized hands-on CB training for military and civil support teams. The WDTC is staffed with a highly responsive and dynamic organization that uses state-of-the-art laboratories, controlled environmental chamber testing, field testing, and CBW training to support the DPG mission. The WDTC features a diverse and dedicated team of scientists, chemists, microbiologists, engineers, technicians, and support personnel who specialize in developmental test and evaluation of chemical and biological defense system testing. The 2012 Capabilities Report consists of the following 10 sections: 1) Dugway Proving Ground Introduction; 2) Dugway Proving Ground Test and Support Facilities; 3) Dugway Test Grids and Training Ranges; 4) Biological Defense; 5) Chemical Test Capabilities; 6) Munitions Testing and Smoke & Obscurants; 7) Dugway Test Support; 8) Meteorology; 9) Specialized Test and Training Facilities and Programs; and 10) Modeling and Simulation.**		

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Foreword

The 2012 Capabilities Report has been expanded to include a more complete look at the myriad of test and test-related capabilities offered at Dugway Proving Ground. New features include: Biological Defense that highlights aerosol testing, microbiological analyses, production of agents and simulants, biosurety/biosafety, and rapid identification of unknown microorganisms; the small item decontamination system; munitions testing; smoke and obscurants; light detection and ranging (lidar) systems; radar systems; test data acquisition; and test event imaging. This edition includes feature articles entitled “Preview the Future” which describes new capabilities that are being developed at the West Desert Test Center. The Publisher wishes to thank the numerous subject matter experts who provided their expertise in the preparation of this report, and especially acknowledge the contributions of the following individuals: Lindsay France, Tracy Lay, Teri Street, James Pearson, Nyle Critchlow, Charles Hobson, Cheri Williams, and the Test Data Imaging Branch for access to the photo archives, along with the many Dugway photographers whose capabilities in their own right are unsurpassed.

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Cover Photo by Charles Hobson: General Atomics' Blitzer™ electromagnetic railgun air defense prototype system test.

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Section 1

Dugway Proving Ground

Introduction

Dugway Proving Ground – Overview and Mission

On February 6, 1942, President Franklin D. Roosevelt withdrew an initial 126,720 acres of Utah land from the public domain for use by the War Department. Six days later Dugway Proving Ground (DPG) was established, with official activation on March 1; testing was underway by that summer.
After World War II the facility was deactivated, but DPG resumed active status in 1950 and a boom of construction and testing followed. In 1968, DPG consolidated with the Deseret Test Center at Fort Douglas, an operation that lasted until 1973 when Dugway became part of the U.S. Army Test and Evaluation Command (TECOM) which later became the Developmental Test Command (DTC). Dugway Proving Ground is currently aligned under the U.S. Army Test and Evaluation Command (Provisional), Aberdeen Proving Ground, Maryland.

Biological defense testing

Today, Dugway is a Major Range and Test Facility Base, with a primary mission to provide developmental and production testing to support the nation's chemical and biological defense programs. Dugway's West Desert Test Center (WDTC) features physical and human resources that create an exceedingly diverse test facility that meets a broad spectrum of continually evolving test and evaluation requirements.
The WDTC facilities, test fixtures, and equipment were designed and built specifically for Dugway's mission with the technology and procedures having been developed by WDTC scientists, engineers, chemists, microbiologists, and technicians.

Dugway's most valuable asset, however, is its workforce. The WDTC technical staff provides expertise in a broad range of physical and life sciences, and has unsurpassed experience in the planning and execution of chemical-biological (CB) test and training programs.

Dugway is the first choice for Army CB defense testing of individual protective equipment (IPE) and collective protection (ColPro) systems, contamination avoidance detection systems, decontamination programs, meteorological technology development, and smoke/obscurants generation and effectiveness.

Chemical testing

Additional capabilities include: systems-of-systems integration, distributed testing, CB and explosive materials emissions characterization, unique training facilities for military units, Homeland Security, and Civil Support Teams, and testing unmanned aircraft systems (UAS). The West Desert Test Center has the capability to create and fabricate unique fixtures, chambers, and instrumentation suites as required to support individual customer test requirements.

Dugway Proving Ground – Setting

Situated about 75 miles southwest of Salt Lake City, Utah (Tooele County), Dugway Proving Ground (DPG) consists of 797,974 acres of Great Basin terrain ranging from level salt flats, to intermittent sand dunes and rugged mountains. Adjacent U.S. Air Force gunnery and bombing ranges extend Dugway's restricted airspace to an area of about 90 miles by 70 miles and up to an elevation of 58,000 feet.

Dugway's 1,252 square miles of sparse desert and restricted airspace provides freedom from urban encroachment and population pressures ensuring distinct and versatile advantages for test planning and execution. Additionally, the DPG test grids and ranges are light pollution-free and acoustically and electronically quiet, which contribute to a test-friendly climate. DPG's average elevation of 4,350 feet above sea level is characteristic of its Great Salt Lake Desert locale but is punctuated by craggy peaks, including 7,082-foot Granite Peak in the center of the installation.

Dugway is bordered to the northeast by the Cedar Mountains and to the south by a series of ranges and valleys, the closest of which is the Dugway Range. The Onaqui Mountains and Davis Mountain are located east of the Army post. The Deep Creek Range lies to the west and marks the boundary of the Great Salt Lake Desert. Extensive basin areas are broken by the topographic relief of the Cedar Mountains, Little Davis Mountain, Simpson Buttes, Camels Back Ridge, Wig Mountain, Granite Peak, and Sapphire Mountain.

Quick Facts
The original configuration of the Lincoln Highway, the nation's first continuous highway from the Atlantic to the Pacific, cut across present-day Dugway Proving Ground. The Lincoln Highway Bridge (built circa 1900*) was listed on the National Register of Historic Places on May 21, 1975*.
**National Register of Historic Places Inventory – Nomination*

Vegetation and animal life is consistent with that found throughout the Great Basin. Small desert plants and hardy grasses and brush are plentiful, with sage and salt brush throughout most of the range. The range also supports healthy populations of wild mustang, pronghorn antelope, mule deer, coyote, bobcat, kit fox, and a variety of rodents. Owl species, especially great horned owl and burrowing owl, along with hawks and eagles are perennially found on post.

Test grids are primarily located in lower-lying areas with reduced levels of animal life, reducing potential adverse environmental impact.

Lincoln Highway Bridge

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Dugway Proving Ground – Climate

For most of the year, Dugway Proving Ground experiences a moderate, high desert climate. Summertime highs regularly exceed 90°F, but low humidity (average 59%) levels yield pleasant daytime conditions and cooler evening temperatures. January is the coldest month on post, with an average minimum temperature of 16°F and average maximum of 37°F.

Springtime rain makes up the majority of Dugway's precipitation, which averages between six and seven inches annually. Winter snowfalls are light (17 inches average), but not infrequent. Nearby mountain ranges such as the Deep Creek, Stansbury, and Wasatch mountains receive significant snowfall, with ski resorts in the Wasatch accumulating 400 to 500 inches annually, and occasionally over 600 inches.

Weather patterns and prevailing winds at Dugway are strongly influenced by its terrain. Prevailing winds are from the northwest during afternoon hours and from the southeast at night and during the morning hours. The salt flats along the western and northwestern borders create a contrasting land surface, and the gently sloping terrain between Camelback and Granite mountains cause upslope or downslope winds. These processes largely determine the prevailing winds during the summer.

The pinnacle-like mountains interspersed in the flat terrain are cooler and receive more precipitation than surrounding areas. These mountains, along with the north-south oriented mountain ranges surrounding Dugway, influence local weather patterns by channeling winds and promoting up-and-down slope conditions in mornings and evenings, respectively.

From late spring to late fall, nighttime atmospheric conditions over the primary test ranges are very stable with the absence of storms, producing a consistent and reliable wind pattern enabling effective test design.

Devil's Woodpile

Atmospheric conditions are typically pristine with surrounding mountain ranges 20-60 miles distant often visible. Visibility exceeds 10 miles about 95% of the time. Occasional hazy conditions are usually natural in origin, as Dugway almost never experiences the inversion conditions of nearby populated valleys. Because of Dugway's testing and research activities, extensive climatological data have been and continues to be collected and are available in electronic and hard copy to aid in field test planning.

Dugway Proving Ground – Environmental Stewardship

U.S. Army Dugway Proving Ground's (DPG) commitment to the environment rests on a four-pillared strategy that includes compliance, restoration, prevention, and conservation. Dugway takes its responsibility for the environment seriously and energetically pursues programs in all four areas. The Integrated Natural Resources Management Plan (INRMP) is the action plan for the care and wise use of lands entrusted to Dugway. Dugway's command and staff are committed to using an ecosystem management approach to its natural resources program. Ecosystem management helps to protect biological diversity and ensure correct decisions are made regarding the use of renewable natural resources to support DPG's military mission and the needs of Utah and the nation. The INRMP helps DPG comply with other federal and state laws, such as regulations associated with environmental documentation, wetlands, endangered species, and wildlife management in general.

Pronghorn

Compliance

Compliance heavily influences DPG's test mission, and test officers assess and address potential environmental impact issues prior to each test. Environmental compliance regulations have increased dramatically over the years and each one presents a challenge. Dugway is regulated by numerous federal and state environmental statutes and is inspected for compliance by the U.S. Environmental Protection Agency and the Utah Department of Environmental Quality among others. The Environmental Technology Office (ETO) reviews all mission test and training programs to ensure compliance with the National Environmental Policy Act (NEPA). These reviews are documented in accordance with Code of Federal Regulations (CFR) Part 651 Environmental Analysis of Army Actions.

The Directorate of Environmental Programs (EP) monitors and inspects all Dugway environmental programs, projects, facilities, and operations, as well as the DPG test and training mission to ensure activities are conducted in accordance with approved environmental policies. EP performs environmental audits to assure adherence to regulatory requirements and to help identify problem areas relative to the environment.

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Restoration


Young coyote

Dugway's environmental program includes restoration, which reflects the commitment to address the environmental impact of test activities that pre-date current environmental regulations. Dugway supports the Army Installation Restoration Program, a comprehensive program to identify, investigate, and remediate hazardous substances, pollutants, and contaminants at active/operating Army installations. The mission for Army active installation restoration is to perform appropriate, cost-effective cleanup to ensure the property is safe for installation use and to protect human health and the environment.

Conservation/Preservation

Conservation and preservation of our natural resources also play a vital role in the management of Dugway test programs. Dugway works with the Utah State Wildlife Resources Division and the Bureau of Land Management to monitor the wide variety wildlife that resides throughout the installation. DPG also takes great pride in its responsibility to protect unique geological formations present within its borders. These areas have been identified by The Nature Conservancy, an international non-profit organization whose local mission is to preserve Utah's natural diversity.


Juvenile Great Horned Owls

West Desert Test Center – Reporting Structure

The West Desert Test Center at Dugway Proving Ground is part of the U.S. Army Test and Evaluation Command which includes the following facilities: Aberdeen Test Center, Aberdeen Proving Ground, Maryland; Electronic Proving Ground, Fort Huachuca, Arizona; Redstone Test Center, Redstone Arsenal, Alabama; White Sands Test Center, White Sands Missile Range, New Mexico; and Yuma Proving Ground, Arizona.

U.S. Department of Defense

U.S. Department of the Army

Army Test and Evaluation Command (ATEC)

Dugway Proving Ground

West Desert Test Center

- Chemical Test Division
- Data Sciences Division
- Dissemination & Explosives Division
- Life Sciences Division
- Meteorology Division
- Special Programs Division
- Test Engineering & Integration Division

West Desert Test Center - Organization

U.S. Army Dugway Proving Ground (DPG), West Desert Test Center (WDTC), specializes in planning, conducting, and analyzing results of developmental and production tests. Areas of expertise include chemical and biological (CB) defense systems, smoke and obscurants, materiel and delivery systems, munitions and incendiary devices, meteorological research and modeling, environmental characterization and remediation technology testing, and technology transfer to include specialized hands-on CB training for military and civil support teams. The WDTC is staffed with a highly responsive and dynamic organization that uses state-of-the-art laboratories, controlled environmental testing, field testing, and CBW training to support the DPG mission. The WDTC features a diverse and dedicated team of scientists, chemists, microbiologists, engineers, technicians, and support personnel who specialize in developmental test and evaluation of chemical and biological defense system testing.

Chemical Test Division

The Chemical Test Division protects the U.S. and its allies from chemical threats through expert planning, management, and execution of developmental and operational testing. Testing includes individual and collective protection equipment, contamination avoidance systems, and decontamination systems and processes. Customer projects are evaluated by division scientists. Project teams are assembled from each branch and draw on a high level of expertise in project design, methodology development, and testing with chemical agents, simulants, and toxic industrial chemicals/toxic industrial materials (TIC/TIM).

- **Chemical Test Branch** manages test projects for the Army and various customers in the areas of chemical defense, including testing of protection, detection, decontamination, integrated platform systems, chemical information systems, and survivability testing. Test directors manage test teams and are responsible for overall planning, cost estimating, financial management, scheduling, conduct, data analysis, evaluation, reporting of results, and retrograde of assigned tests and programs. Branch scientists direct research projects to develop new, or adapt or improve existing chemical, biochemical, physical, and instrumental sampling and analytical techniques and procedures used to analyze chemical agents and simulants, and in the detection and analysis of environmental pollutants.
- The **Test Execution Branch** provides certified, accredited technicians who install, calibrate and perform operational checks of complex real-time detection and monitoring equipment used to detect toxic chemicals and simulants in support of the test mission. Scientists and chemists conduct physical and chemical analyses of agents, simulants, tracers, and toxic industrial materials. The branch operates and maintains the Combined Chemical Test Facility, Building 3445, Defensive Test Chamber, Bushnell Materiel Test Facility, and other facilities in support of simulant and chemical agent test requirements. In addition, the branch supports chemical surety transfer operations, special chemical surety investigation operations (range recovered ordnance), and other chemical surety related activities requiring total containment.
- **Chemical Science Branch** staff plans, conducts, evaluates, and reports on methodology improvement programs to refine and improve test capabilities, operational processes, test design, analytical procedures, and test data. Scientists provide technical expertise in the areas of chemical agents, simulants, and pollutants and their detection, collection, sampling, and analysis. Branch staff identifies requirements and provides input and specifications for the design and improvement of test systems to meet data and accuracy requirements for specific tests. The branch develops, coordinates, and administers the division Quality Management System.

Data Sciences Division

The Data Sciences Division manages the WDTC information technology systems, provides data planning and analysis services, and programming and software development support. The preeminent component of WDTC information technology is the Test Mission Support System (TMSS) which collects, transfers, and stores test data.

Information assurance (IA) measures protection and defends the information and information systems by ensuring availability, integrity, authentication, confidentiality, and non-repudiation. Measures include managing risks related to the use, processing, storage, and transmission of information or data and the systems and processes used for those purposes, and providing for restoration of information systems by incorporating protection, detection, and reaction. IA encompasses not only digital information but the physical security and environment controls that house those systems.

- The **Test Design and Analysis (TDA) Branch** serves as test program data team leaders and data managers for WDTC tests/experiments. TDA is involved from the planning stage (creating test matrices using design of experiment techniques, establish data streams and instrumentation requirements, and creating the data management plan) through data archival. TDA also plans the data collection, merges and reduces raw test data, performs statistical analysis, and provide customized data packages such as graphs, tables, and test incident reports. The branch provides direct test support through modeling and simulation (M&S) at appropriate levels of fidelity to support CB and other test programs.
- **Systems Architecture (SA) Branch** manages the Test Mission Support System (TMSS), the overarching enterprise environment that supports the test mission at WDTC. The SA branch provides data transport from acquisition to archive via the test network (TNET) and facilitates the connection to the RDT&E community utilizing the Defense Research and Engineering Network (DREN). In addition, the SA branch provides secure data storage for information collected from field and laboratory tests. The SA branch also creates procurement requests for IT requirements for WDTC, and develops custom systems and software for requirements that have no off-the-shelf solution. The branch maintains and operates the Distributed Test Control Center (DTCC), which provides the capability to control and observe local testing on the range as well a capability to participate in distributed tests.

Dissemination and Explosives Division

The Dissemination and Explosives Division supports other WDTC organizations, such as the Chemical Test Division, Life Sciences Division, and Special Programs Division, in test trials that require dissemination of chemical-biological (CB) simulants and battlefield interferents, or tests involving explosive detonations. Division personnel maintain and operate test sites, firing ranges, and bunkers for artillery, mortars, mines, insensitive munitions, and other explosives.

- **Dissemination Branch** staff prepare and disseminate CB simulants (liquid, vapor, aerosol, or powder), toxic industrial chemicals (TIC), and battlefield interferents for outdoor and chamber testing through an array of mobile, stationary and explosive dissemination systems. Branch technicians have the unique capability to produce large quantities (up to 55 gallons) of liquid chemical simulant and TICs for dissemination during field tests. Dissemination and explosives specialists can design and fabricate new dissemination equipment or fixtures to meet customer requirements.

- The **Explosives Test Branch** maintains, deploys, functions, and operates weapons systems in support of the WDTC mission. Certified operators handle and transport munitions, explosives, ammunition, and ammunition components, as well as locate, recover, and dispose unsafe munitions. The branch provides unexploded ordinance (UXO) support for Dugway Proving Ground and the WDTC.
- The **Smoke and Obscurants Branch** supports military programs on developmental smoke and obscurant producing munitions testing, as well as illuminating munitions testing and characterization. The branch utilizes smoke, obscurants, and battlefield interferents in support of CB detection system tests and to provide smoke and battlefield contaminants during air filtration systems tests.
- **Ammunition Accountability** coordinates the receipt, storage, and distribution of ammunition. Chemical surety material and emerging threat material used at Dugway are under surety control procedures established in accordance with DoD, U. S. Army, Army Test and Evaluation Command (ATEC), and DPG regulations. All munitions and agents are placed into storage that meets compatibility and explosive license requirements in accordance with security procedures. Ammunition Accountability staff also manages the Commander's Amnesty Program for the test center.

Life Sciences Division

The Life Sciences Division (LSD) blends the expertise of its dedicated staff with state-of-the-art facilities to conduct developmental and operational testing of biological defense systems and medical countermeasures programs for the Department of Defense (DoD) and other federal government and microbiological industry clients. Scientists, microbiologists, and technicians design, implement, and validate biodefense programs for protection and detection systems utilizing biosafety laboratories, unique environmentally-controlled aerosol chambers, and Dugway's outdoor test grid.

- The **Aerosol Technology Branch** operates biosafety laboratories and test fixtures capable of safely aerosolizing biological simulants and select agents to test biological detection systems and the effects of contamination/decontamination on material and equipment. Branch test officers have extensive experience supporting large, outdoor biological simulant aerosol test programs. Capabilities include biodefense system testing with simulants and agent-like organisms (ALO) within BSL-1 and BSL-2 laboratories and chambers, and the only DoD-certified BSL-3 chambers to test with live, aerosolized biological warfare agents, bacteria, viruses, and biological toxins. A ≈4000 ft^3 BSL-3 whole-system live agent test (WSLAT) chamber is expected to be on-line in 2012, providing Dugway with an internationally distinct capability.
- **Microbiology Branch** scientists and microbiologists support Dugway test programs, the DoD, and federal agencies, such as the Center for Disease Control and Prevention (CDC), with: bacterial and viral analysis, genetic molecule analysis (including genome sequencing and optical mapping), protein molecule analysis, and microbial identification analysis. Microbiology branch biological production capabilities include threat-representative select agents, toxins, bacteria and viruses, plus ALOs used in chamber and field testing. A post-production laboratory dries and mills test materials. The branch serves as the antigen repository for the Critical Reagents Program (CRP) and is an Accredited Certified Reference Material (CRM) Producer (ISO 17025 and 34.2009).

- The **Regulatory Science and Innovation (RSI) Branch** protects the workforce, public, and environment by ensuring that all tests and training programs performed within LSD are safe and in compliance with all federal, state, DoD, and Army regulations. RSI staff provides leading-edge development and validation of new or improved methods for agent analysis, simulant development, and focused tests to simulate battlefield or other customer-required environments. The RSI staff consults with test directors, program managers, and other customers for the best innovative practices to comply with unique and new technologies used in biological testing to meet all biological safety, surety management, and compliance regulations for biological test programs. Training specialists (microbiologists) conduct internal microbiological courses for Life Sciences staff, as well as hands-on biological training for military and civilian emergency response personnel, including signature recognition, detection, identification, and hazard analysis. RSI specializes and consults on large-scale decontamination tests with different decontamination modalities based on the area being decontaminated. RSI also performs small and medium scale decontamination operations in addition to equipment decontamination and validation. RSI is dedicated to the effort and capabilities of enabling biosurveillance through coordinated and integrated national and international systems, as well as among federal, state, local, tribal governments, and the private sector.

Meteorology Division

Dugway's Meteorology Division is the oldest continuously operating weather and climate organization in the Army. Today it provides meteorological, climatological, and test support for DPG; weather modeling support for all other Army test ranges and proving grounds; meteorology project management for CB defense atmospheric transport and dispersion (ATD) model development and validation; and serves as program manager for the ATEC Research, Development, Test and Evaluation Operational Meteorology Program.

- The **Meteorology Operations Branch** assists test officers and customers in large chamber and field test planning, execution, and analysis through weather forecasts and warnings, surface and upper-air observations, near real-time ATD modeling for CB and obscurant tests, and utilization of a wide array of data collection instrumentation. The branch maintains the climatological database for the DPG weather station, remote automated weather stations, and upper-air observations.
- The **Modeling and Assessment Branch** tests, evaluates and validates new numerical weather prediction and ATD models related to CB defense, including organizing and participating in national and international CB data collection experiments/tests, and independent verification and validation of meteorological and CB defense ATD models. The branch provides a full range of ATD modeling, supporting test planning, execution, and post-test data analysis. Branch staff conducts research studies related to complex terrain effects on various range test grids and manages Dugway's meteorology program to identify new instrumentation requirements, and to adapt new theoretical and empirical developments in meteorological modeling and forecasting, in support of WDTC and its customers.

Special Programs Division

The Special Programs Division (SPD) staff is a unique blend of technical personnel that includes PhD-level physical scientists, chemists, engineers, and microbiologists, plus former civilian and military operators with chemical, biological, or explosives expertise. SPD specializes in planning, conducting, and analyzing results of non-acquisition Chemical, Biological, Radiological, Nuclear, and Explosive (CBRNE) warfare defense systems. Division personnel provide training for military and civilian emergency response personnel to operate in a chemical/biological/energetics (CBE) warfare or contaminated environment, which includes classroom instruction, practical laboratory exercises, and field training.

- The **Test Management Branch** is responsible for managing non-traditional CBRNE test and evaluation (T&E) programs and serves as the focal point to market WDTC non-traditional test capabilities to the government, industry, and academia. Branch staff provides technical advice to WDTC and its customers in the areas of CBRNE unique threat assessments, test management, advanced concept technology/advanced technology demonstrations, and chemical/biological (CB) defense operational T&E. Test officers, scientists, and subject matter experts (SME) develop and execute test requirements for non-traditional customers, that involve non-CB acquisition T&E, as well as explosives and toxic industrial chemicals/toxic industrial materials (TIC/TIM) operational and acquisition assessments. Through matrix management and cross-training of staff, SPD can apply results achieved from a test and immediately apply it to a customer training course.
- The **Training and Operations Branch** provides classroom and laboratory instruction, plus CONUS and OCONUS training scenarios in chemical, biological, and homemade explosives (HME) threat recognition, incident response, detection, and sampling for select DoD and civilian personnel. On-site training facilities include dedicated chemical and BSL-2 laboratories, real-world test beds and training sites, and the outdoor test grid and training range. SPD provides training program video documentation; secure, classified communications capabilities; and classified video teleconferencing. Instructors include technical CBRNE specialists and former military and government operational CBRNE subject matter experts. Courses may be delivered at the Dugway specialized training facilities or at a customer site.
- The **Project Science Management Branch** is responsible for technical, methodology, and quality management and support for non-traditional CBRNE test and evaluation programs; and training and operations instruction. Branch personnel ensure the accuracy, reliability, and confidence in project test data. Scientists and SMEs provide expert advice to WDTC and its customers in the areas of CBE, TICs/TIMs, physical, mathematical/statistical, meteorological and operational principles which require a systematic approach to resolve variables by devising new test methodologies and procedures.

Test Engineering and Integration Division

The Test Engineering and Integration Division (TEID) provides integrated technical support to WDTC test customers through its instrumentation and control systems, test fixture engineering, test data and visual image collection, large-scale military equipment test facilities, and field test support. TEID staff supports all chemical-biological (CB) laboratory, chamber and field test programs, munitions and explosives test events, and optical support for Unmanned Aircraft System (UAS) test programs.

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- **Engineering Branch** personnel design and build 3D models, fabricate and validate complex test fixtures, and perform computational fluid dynamics modeling to support design and test data comparisons. Employing advanced CAD software, such as Creo Elements/Pro, AutoCAD®, and FLUENT, engineers apply their mechanical, electrical, and pneumatic expertise to design test fixtures and structures to meet specific WDTC and customer requirements. The branch manages the WDTC combined test facilities, such as the Joint Ambient Breeze Tunnel and Decontamination Pad Test Facility, and designs special fixtures to support dynamic and environmental testing to MIL-STD-810G standards. The Engineering Branch is developing the processes to establish and manage a new WDTC Test Material Distribution Center.
- The **Electronics Branch** develops, maintains, and operates data acquisition systems to support field testing with instrumentation and control (I&C) equipment such as optics, radar, lidar, telemetry, and GPS. Branch scientists and engineers design and implement I&C systems using LabVIEW™ software and National Instruments hardware, and PAC Project software and Opto 22 hardware. The staff can create unique interfaces to adapt customer hardware, such as ppbRAE, GLC-M21 units, and Gasmet™ for data collection. The Electronics Branch maintains and deploys electronic interfaces and test support equipment for customer tests on the complex Test Grid Upgrade Project Range.
- **Test Data Imaging Branch** offers a full menu of optical products and services with capabilities ranging from still photography to state-of-the-art active and passive remote detection methods, such as light detection and ranging (LIDAR) and chemical cloud tracking systems (CCTS). Customizable graphic designs with large-format printing may be augmented with full video and multimedia productions. Branch technicians produce standard definition, high definition, and high-speed video in both fixed-view and tracking modes. Thermographic data collection services using infrared cameras can be obtained for normal, low-light, and obscured conditions, including precise temperature measurements ranging from -40° to 1,500°C. Advanced technical services, such as passive chemical tracking and active standoff tracking, are performed by branch personnel at the WDTC and other test ranges with customizable data products available for customers.
- The **Range Support Branch** builds, modifies, and maintains the WDTC test grids and training range, which includes: providing climate-controlled control rooms; movement of test command posts, fixtures, and customer equipment to and from test sites; and preparing cost estimates and completion timelines. The branch supplies civil design services and construction of grid infrastructure, including construction expertise for customer test fixtures and facilities, soil excavation, road grading, heavy equipment operation, and heavy lifting to 40 tons. Range Support also provides electrical/power design for test apparatus, fixtures, and test grids. Branch technicians set up, operate, and maintain microwave systems for the collection and transmission of unencrypted data to the WDTC network. Other services provided include field surveying, model making, and machine shop operation and test equipment fabrication. Machine shop equipment includes: a 2 axis CNC water jet, two 2 axis CNC lathes, two manual Bridgeport milling machines, a 3 axis CNC end mill, and general shop and welding fabrication equipment. The electrical shop provides portable generators and power supply design and installation for electrical supply in remote locations.

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Section 2

Dugway Proving Ground

Test and Support Facilities

Ditto, Michael Army Airfield, and Avery Complex

Dugway Test and Support Facilities

U.S. Army Dugway Proving Ground (DPG), as a Major Range and Test Facility Base (MRTFB), is the first choice for chemical/biological defense developmental and production test and evaluation programs necessary to support Department of Defense (DoD) initiatives and national security.

The West Desert Test Center (WDTC) features a diverse assortment of facilities that were designed and built specifically for Dugway's mission to ensure that vital equipment and protection systems used by warfighters and peacekeepers, both at home and abroad, meet or exceed the highest military standards. DPG provides a full range of testing concepts from small, controlled chambers in laboratories, to semi-controlled environments in a mid-sized facility, such as the Joint Ambient Breeze Tunnel, to the large, real-world environment during field trials.

Chemical Laboratories and Test Chambers

Reginald Kendall Combined Chemical Test Facility (CCTF) – A 35,000-square-foot facility used to support chemical testing and evaluation of individual protective equipment (IPE), collective protection equipment (ColPro), detectors, and the effects of decontamination on equipment and systems. Test officers and technicians can challenge test materials with a comprehensive list of traditional and emerging threat agents, plus chemical simulants in liquid, vapor, or aerosol form to determine the functionality and survivability of military equipment. Scientists and chemists analyze agents, simulants, and other analytes in samples, collected from laboratory and chamber trials, to provide accurate data to customers as well as to ensure compliance with EPA, state, and local regulations.

The CCTF state-of-the-art capabilities to deliver customer tests include:

- 30 laboratories supporting test and methodology development
- Over 60 analytical instruments used for the separation, quantification, and identification of chemicals

- Fourier Transform Infrared (FTIR) and Raman microscopes, ultraviolet-visible spectrometers, time-resolved florescence spectrometer, and a laser aerosol particle analyzer to perform surface analysis, non-invasive characterization, and particle size analysis of nonstandard samples
- A 600-MHz Nuclear Magnetic Resonance (NMR) Spectrometer interfaced with Liquid Chromatography-Mass Spectroscopy instrument allows chemical compound confirmation and identification. It is used to perform quantitative analysis and elucidate chemical structures.
- Over 270 MINICAMS®, 150 ppbRAE photoionization detectors, and 53 portable infrared and FTIR detectors for safety air monitoring
- 47 agent certified fume hoods and five standard fume hoods within 27 surety-capable test suites
- Agents: G agents, VX, H-Series, Lewisite
- Simulants: 13 licensed simulants
- Aerosol, vapor, and droplet testing

The CCTF also houses swatch testing facilities, the Swatch Including Filter Test (SWIFT) system, the Immersion Chamber, and the Simulant Agent Resistant Test Manikin (SMARTMAN) system.

Chemical Testing Auxiliary Facilities

Laboratory Building 4165 – Known as the "old chemistry laboratory," this renovated building includes 14 laboratory fume hoods and one fume hood in each of the two test areas. Laboratory Building 4165 houses the Dynamic Test Chamber, Small Item Decontamination Fixture/Multi-Decontamination Chamber, and is the future home of the programmable Individual Protection Ensemble Mannequin System (IPEMS), currently being developed by the WDTC, PD CCAT&TI, MRIGlobal, Boston Dynamics, and other companies.

Building 3445 – Certified to test with chemical agents and chemical/biological simulants, the facility includes 2210-square-foot East and West chambers, plus outside laboratory and control facilities. Building 3445 is located within the Carr Test Support and Storage Complex and houses the Novel Closures Test Fixture (East) and the Advanced Air Purification Test Fixture (West).

Melvin Bushnell Materiel Test Facility (MTF) – The MTF is a live-agent test chamber that can accommodate large-scale military vehicles and equipment and provide extreme environmental test conditions. Located southwest of the Carr complex, the custom-built test chambers and fixtures within the MTF are used to challenge detection, protection, or decontamination systems with high concentrations of chemical warfare agents (CWA) or chemical and biological simulants.

Melvin Bushnell Materiel Test Facility

The facility monitoring and control center allows for observation during tests, test equipment monitoring, and data and video recording. Additional features include a controlled security system, UPS system, compressed dry air,

Fume hood and glove boxes inside MTF Closed System Chamber

decontamination supply, low-pressure steam and a vacuum system. The 50'w x 50'l x 25'h stainless steel Multi-Purpose Chamber can accommodate any military equipment that meets NATO shipping requirements. The facility has been used to perform tests on items as large as an M1 Abrams Main Battle Tank (engine running).

Environmental controls provide temperature ranges from -40° to 60° C, relative humidity control from 10 to 90%, and agent/simulant concentration up to 1,000 mg/m³. The Agent Transfer Chamber supports agent transfers, dissemination, and monitoring, and includes a glove box test area. The fume hoods have controlled airflow and the storage vault provides on-site agent storage. The Closed System Chamber features pneumatically sealed air locks and can support testing with glove box and specialized test fixture systems.

Biological Laboratories and Test Chambers

Lothar Salomon Life Sciences Test Facility (LSTF) – The LSTF is the only DoD facility certified to test developmental equipment with aerosolized Biosafety Level 3 (BSL-3) agents, including bacteria, viruses, and biological toxins. The 33,150 square-foot facility features BSL-1, BSL-2, and BSL-3 laboratories, and houses the BSL-3 Containment Aerosol Chamber and BSL-2 Aerosol Simulant Exposure Chamber. The laboratory is compliant with Department of the Army, Center for Disease Control, and U.S. Department of Agriculture standards.

Life Sciences test complex

Microbiology capabilities within the LSTF include:

- A fermentation facility designed to produce simulate and agent-like organisms (ALO) for biological defense testing
- A full suite of BSL-3 and BSL-2 laboratories utilized for biodefense test and evaluation (T&E) with biological select agents and ALOs
- A biomolecular laboratory for full characterization and quality analysis of test materials and quantification of referee samples accumulated during test events
- A genotyping laboratory with full or partial genome sequencing of bacteria and viruses

- An Abbott PLEX-ID™ system for rapid identification of unknown microorganisms directly from a sample
- Post-production laboratory for drying and milling test materials used in biodefense T&E
- Virology and tissue culture laboratory for production of select agents and ALOs
- Infrastructure and laboratories to house and conduct testing on mammals
- Scanning electron microscopy for high-resolution interrogation of biological test material and environmental samples
- Water testing capability for handheld individual water purification devices used by deployed personnel
- Environmentally controlled chambers for testing under specific temperature and humidity conditions
- Serves as steward of the Critical Reagents Program antigen repository

The LSTF has been designated for the centralization of mobile biological point detection test equipment. The safari-enabled inventory at LSTF provides up to 10 traditional outdoor referee towers for field tests. LSTF regulatory and science innovation capabilities include: large space decontamination and validation, biological surety and safety compliance, method development, training labs and personnel, and microbiological assay laboratory.

Life Sciences Auxiliary Facilities

Baker Laboratory – Dugway's original biological laboratory, built in 1952 and replaced by the LSTF, has undergone a renovation of approximately 17,000 square feet of space to accommodate the growth in the mission areas of biological detection, protection, and decontamination. The renovation provides additional lab space to work with biological agents, decontamination utilities, and multiple protective security systems.

An approximate 4000-square-foot **Whole System Live Agent Test (WSLAT) Full System Chamber** is under construction in Baker Lab, featuring a BSL-3 aerosol chamber with temperature, humidity, and wind speed controls designed to challenge large items with biological agents. WSLAT methodology will determine if reliable agent-to-simulant correlation is maintained from chamber test data to field testing. Once operational, the WSLAT containment chamber will be used to referee and validate the Joint Biological Point Detector System (JBPDS) and other field biological point detectors. Full operational capability is estimated for 2Q, 2012.

New facilities inside renovated Baker Laboratory

Building 2032 – Building 2032, located at the Life Sciences Test Facility complex, has been renovated to house laboratories, equipment, and systems for the production of microorganisms used in bioaerosol chamber and field test programs. Building 2032 contains fermentation equipment (100L, 150L, 300L and 1500L) to produce ALOs for outdoor biological developmental and operational tests; a gamma irradiator; and small-scale and bulk milling equipment to produce milled test material, such as spores of Bacillus atrophaeus (BG) and Bacillus thuringiensis var. kurstaki (Btk).

Bulk fermentation systems inside Building 2032

Ambient Breeze Tunnel (ABT) – The ABT is an outdoor structure (46x6x6 meters) approved for biosafety level (BSL-1) work. The interior tunnel is used to test biological point and standoff detection systems and referee equipment. The ABT can be used to control cloud concentrations over time and minimizes the effects of weather during test trials. See **Ambient Breeze Tunnel** for more information.

Biological Training Facilities – Life Sciences training staff provides expert instruction and materials to fulfill Dugway's mission for biological defense. Facilities include a BSL-2 training laboratory, rogue labs, a simulant chamber, and a working DoD test facility to familiarize students with equipment and processes.

Training includes biological sampling (surface and aerosols), detection, signs and symptoms, and decontamination. Students work with biological simulants and attenuated strains of some bacterial agents, including microscopic work and practice using field expedient and laboratory analytical techniques. Simulated biological incidents and realistic clandestine laboratory scenarios are staged where students practice threat recognition and sampling skills.

Course topics include:

- Fundamentals of Microbiology
- Biological Agents
- Aseptic Techniques and Sampling
- Analytical Techniques
- Decontamination
- Bio-agent Production Methods/Signature Recognition
- Aerosol Generation and Sampling

TOC

Carr Test Support and Storage Complex

Multiple Purpose Facilities

Active Standoff Chamber (ASC) – The ACS provides a controlled, static environment to test and evaluate chemical-biological (CB) standoff detection systems from 0.5 to 3.0 km with highly-stable (non-dynamic) cloud conditions. The ASC dissemination systems generate CB simulant vapor and aerosol challenges, using transparent air curtains to contain the simulant cloud inside the chamber, to evaluate detector performance without weather interference. The facility is also used to calibrate standoff light detection and ranging (lidar) referee instrumentation. See the Active Standoff Chamber for more information.

Joint Ambient Breeze Tunnel (JABT) – The JABT is a 550-foot facility capable of challenging laser-based detector and point detector systems with a controlled, dynamic cloud under ambient environmental conditions. Stationary or moving clouds are disseminated with CB simulant vapors or solid/liquid aerosols and range in size from approximately 20 m to 100 m in length. Variable pitch fans create field-like conditions to generate wind speeds up to 6.0 m/s (13.42 mph). See the **Joint Ambient Breeze Tunnel** for more information.

Joint Ambient Breeze Tunnel (left) and Active Standoff Chamber

Carr Test Support and Storage Complex – The 140-acre Carr complex is a primary facility for testing, training, and dissemination activities conducted at Dugway Proving Ground. The complex has a variety of test and support facilities, such as: Building 3445, Carr Chemical Chamber, Barrel Storage Facility, Carr Illumination Range Support Structure, and maintenance buildings. Munitions and explosives (e.g., ordnance, top secret and classified munitions) are stored in secured areas at Carr; the Dissemination and Explosives Division also manages 42 portable magazines. The complex houses various custom-built chambers that are used to test military equipment reliability and durability under environmental, climatic, and dynamic conditions.

Michael Army Airfield (MAAF) – This airfield features a lighted 11,000 X 150-foot runway for departures and 10,000 feet for landings, a 9,000-foot taxiway, and a 20,000-square-foot hangar, flight operations, and ground support personnel. MAAF is equipped to handle commercial and military aircraft, with some seasonal restrictions, and can accommodate several types of instrument approaches.

Airfield uses include: tactical air operations, testing aircraft chemical-biological decontamination survivability, transportation to and from nearby drop zones, air re-supply and logistics, and testing of unmanned aircraft systems (UAS). MAAF staff can support exercises or contingency operations on a 24/7 basis will little or no augmentation. The airfield has been a safe haven for aircraft with in-flight emergencies.

Michael Army Airfield is the home of the Rapid Integration and Acceptance Center (RIAC) which tests UAS payloads and technologies to allow for faster deployments to U.S. warfighters. Construction of the first four hangars (for Hunter, Shadow, and Warrior UAS) has been completed, with plans to complete two additional hangars (ranging from 6,000- to 30,000 square feet) to accommodate the testing, maintenance and training of operations personnel on specific air vehicles within RAIC. Each system will have an exclusive area around the flight line for ground-control equipment.

UAS Shadow at MAAF

Dugway Proving Ground is co-located within the Utah Test and Training Range (UTTR), which includes 7,954 square miles of restricted air space, to 58,000 feet, including 1,299 square miles under DPG control. The UTTR is divided into North and South ranges (along the I-80 corridor in Tooele County) with a footprint of 2,675 miles of ground space encompassing over 19,000 square miles of air space when combined with the military operations areas. The UTTR is currently the largest overland continuous block of supersonic authorized restricted air space in the continental United States.

The U.S. Air Force 388th Range Squadron operates and maintains the UTTR, providing responsive open-air training and test services that support operational test and training programs from Hill AFB, large force training exercises, and large footprint weapons testing. The UTTR is used for disposal of explosive ordnance, testing of experimental military equipment, and ground and air military training exercises. In 2011, MAAF was the site of the Manned-Unmanned System Integration Capability (MUSIC) demonstration that exhibited the Army's ability to coordinate, communicate, and share data in an operational environment with ground troops. MUSIC focused on the integrated capabilities of UAS, and the Apache Attack and Kiowa Warrior helicopters.

Joint Ambient Breeze Tunnel

Joint Ambient Breeze Tunnel

Division: *Test Engineering & Integration* **Branch:** *Engineering*

Capability Summary

The Joint Ambient Breeze Tunnel (JABT) is a mid-sized, semi-controlled facility where vapor and aerosol clouds are generated to test and evaluate chemical and biological (CB) point and standoff detection systems under dynamic conditions. The JABT has also been used for referee instrumentation calibration, simulant cloud characterization, and airflow mapping of collective protection systems.

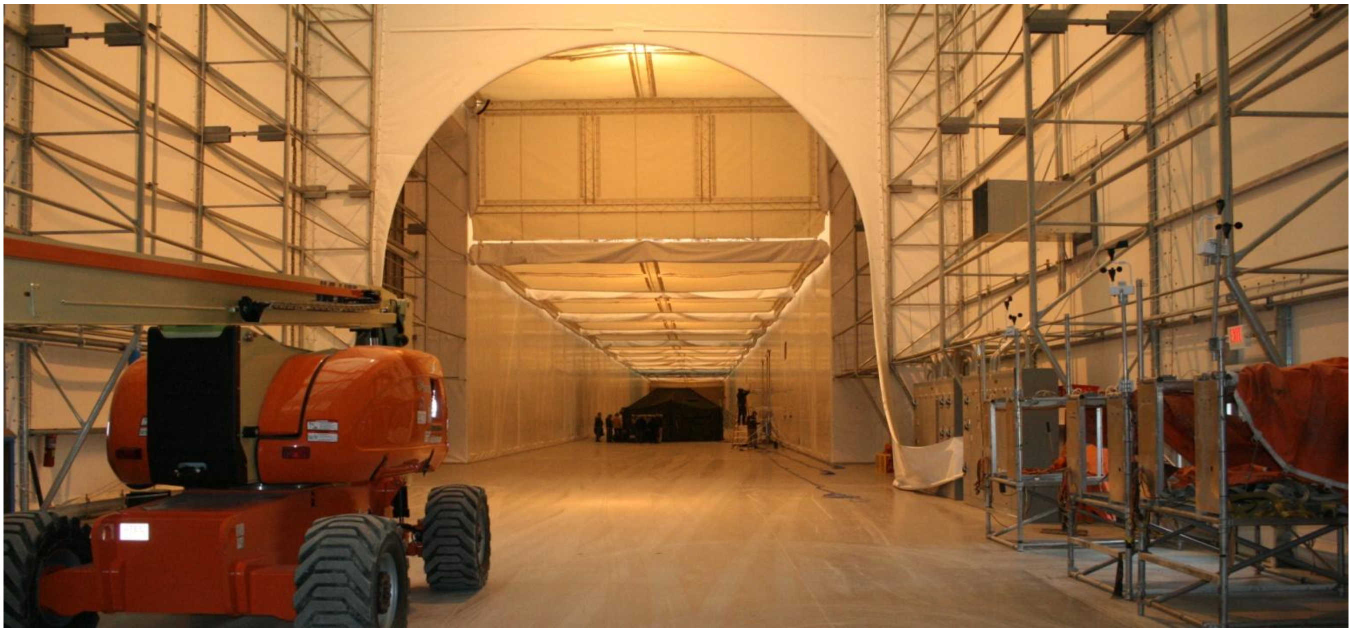
Simulant clouds from 20 to 100 meters in length can be generated with cloud properties being either maintained or varied depending upon required test conditions. A wide variety of chemical-biological (CB) simulants and battlefield interferents may be disseminated with the JABT such as: methyl salicylate (MES), triethyl phosphate (TEP), acetic acid, wet and dry *Bacillus atrophaeus* (BG), *Erwinia herbicola* (EH), ovalbumin (OV), and smoke and dust. Although testing within the JABT does not replace field testing, it provides a controlled facility for instrument developers to test systems without weather interference while using less simulant compared to initial outdoor developmental tests.

System Description

The 550x42.5x59-foot JABT is mounted on a steel-reinforced concrete pad that has a slight slope toward the center to facilitate drainage and to collect liquids from decontamination and cleaning. Each end of the JABT has a 45-foot rollup door that may be raised or closed during test operations. The exterior cover of the JABT is a 28-ounce polyester fabric with a Tedlar® coating and heat-sealed seams; an inner Tedlar® cover protects the interior steel superstructure from corrosion.

East door of JABT

Zones within the JABT include: a challenge generation zone, located at one end of the tunnel; the central test zone; and an exhaust zone located at the opposite end of the tunnel. The JABT features an inner ceiling that may be raised to full height for standoff detector challenges or


Inside Joint Ambient Breeze Tunnel

lowered to a height that utilizes a seven-meter aperture to challenge point detection systems. This flexibility in ceiling height allows a test officer to design trials with a minimal amount of simulant to create a challenge cloud.

Control room operators disseminate and monitor simulant chemical vapors, chemical liquid and solid aerosols, biological liquid and dry aerosols, or interferents/obscurants from portable dissemination carts or a ceiling nozzle array. Smaller releases can be accommodated with a sleeve inserted into the chamber.

Six variable-speed blowers can produce airflow volumes up to 900,000 cubic feet/minute to transport the cloud through the chamber at speeds ranging from 0.2 to 6.0 meters per second (0.4 to 12 mph). Challenge cloud properties and concentration may be either maintained or varied depending on test requirements. Maximum spatial and temporal concentration variation is ±30%. Sensors located along the tunnel do not interfere with the cloud movement or detector line-of-sight, while referee instrumentation may include ppbRAE monitors, Gasmet™ FTIR analyzers, or light detection and ranging (lidar) systems.

Exhaust blowers create a negative pressure in the test chamber and pull the cloud through high-efficiency particulate air (HEPA) filters prior to exhausting the air into the atmosphere. The JABT has a backup diesel generator to ensure safety of personnel and equipment in the event of a power outage.

Current and future programs supported by the JABT include: Next Generation Chemical Standoff Detection (NGCSD), Joint Biological Standoff Detection System (JBSDS), Joint Biological Tactical Detection System (JBTDS), Joint Biological Point Detection System (JBPDS), and Joint Expeditionary Collective Protection (JECP).

Quick Facts

JABT Dissemination Parameters

Parameter	Range
Vapor Concentration	0.1 – 500 mg/m^3
Liquid Aerosol Concentration	100 – 10,000 ppL
Dry Aerosol Concentration	500 – 100,000 ppL
Liquid Aerosol Size	1 – 500 µm
Dry Aerosol Size	1 – 500 µm

Active Standoff Chamber

Division: *Test Engineering & Integration*
Branch: *Engineering*

Active Standoff Chamber

Capability Summary

The Active Standoff Chamber (ASC) is a large-scale, temperature-controlled environment where homogenous vapor and aerosol clouds of known size, shape, speed, location, chemical content, and particle distribution can be generated and controlled. The ASC is primarily used to test candidate chemical and biological standoff detectors without weather interference, as well as to calibrate referee instruments, such as light detection and ranging (lidar) systems.

The dissemination system is capable of generating a simulant cloud and maintaining concentration consistency of ±5% or better during a 15-minute test period. The system can disseminate a wide variety of chemical-biological (CB) simulants such as: methyl salicylate (MES), triethyl phosphate (TEP), acetic acid, chemical dust (kaolin), and *Bacillus atrophaeus* (BG). Although testing within the ASC does not replace field testing, it provides a controlled facility for instrument developers to test systems without weather interference while using less simulant compared to initial outdoor tests.

System Description

The ASC is approximately 131x18x14 meters (430'x59'x45') with tapered ends and houses a stainless steel dissemination chamber (approximately 31.5x4.1x6.4 meters) designed to hold a continuous chemical or biological vapor, aerosol, or liquid droplet challenge. Temperatures inside the chamber can be set to operate between 40° and 95°F.

The top, bottom, and two sides of the dissemination chamber provide a physical barrier to contain a continuous challenge. Air curtains on each end outside of the dissemination chamber provide a semi-permeable barrier to minimize leakage to no more than 0.0001 mg/m³ and a transparent window for all standoff detectors and referee equipment. The chamber's containment system includes HEPA and carbon air filters to capture particulates and ensure releases into the environment do not exceed regulatory permitted levels.

The ASC generates a CB simulant cloud under static conditions inside a 30-meter chamber with a three-meter aperture allowing CB detectors to be tested at distances ranging from 0.5 to 3.0 km. Although designed primarily to test CB detection systems, the ASC can be used in any test program requiring statically controlled cloud concentration and particle sizes with no physical barrier between the system under test (SUT) and challenge conditions.

Current and future programs supported by the ASC includes: Chemical Biological Detection System (CBDS), Joint Biological Standoff Detection System (JBSDS), and Next Generation Chemical Standoff Detector (NGCSD).

Quick Facts

ASC Dissemination Parameters

Parameter	Range
Vapor Concentration	0.5 – 300 mg/m^3
Liquid Aerosol Concentration	500 – 10,000 ppL
Dry Aerosol Concentration	300 – 100,000 ppL
Liquid Aerosol Size	1 – 500 µm
Dry Aerosol Size	1 – 30 µm

TOC

Section 3

Dugway Test Grids

Training Ranges

Dugway Test Grids and Training Ranges

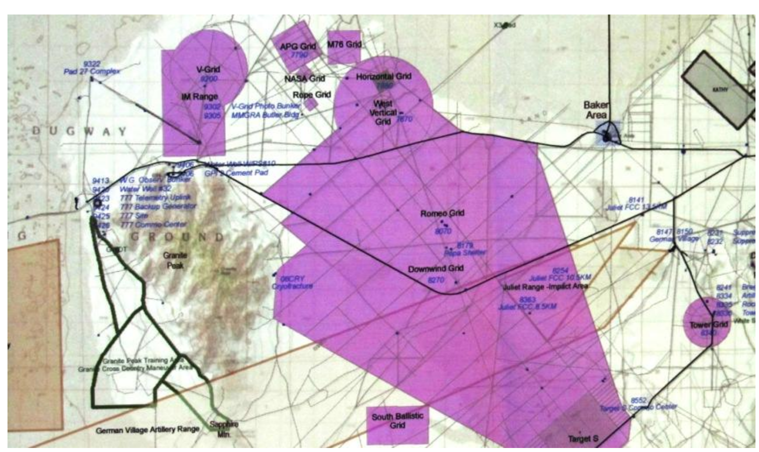
Since the inception of Dugway Proving Ground (DPG) in 1942, western Utah's landscape of flat high desert mixed with mountainous terrain and sand dunes, along with an arid climate, has served as the backdrop to ensure that the U.S. military is the best equipped and best trained force in the world.

Encompassing over 900 square miles of DPG, the test grids, open-air ranges, impact areas, and training facilities are used for field testing of chemical-biological (CB) detection, protection, and decontamination equipment, munitions testing and training, unmanned aircraft system (UAS) tests, tactical air operations, training military forces, and training civil support teams to operate in a CB-contaminated environment.

Data from developmental and operational field testing supports military acquisition decisions to determine whether materiel or systems meet quality and functionality specifications and operational requirements. The Great Basin terrain, climate, and environment reflects those parts of the world where U.S. warfighters are currently deployed, providing a unique training ground to prepare U.S. and allied forces to successfully complete their missions.

In addition to CB defense testing, technology development, and military training, the grids and ranges are utilized for:

- Testing with toxic industrial chemicals/toxic industrial materials (TIC/TIM)
- Meteorological model development and validation
- Equipment reliability, durability, and performance in extreme weather
- Smoke, obscurant, and illuminant systems
- Characterization of air emissions from open burn/open detonation of obsolete or unsafe munitions
- Civil emergency management/first responder training
- National Guard maneuver training
- Emerging threat and technology characterization
- Field artillery/mortar activities
- Counterterrorism training
- Synchronized joint military ground and air exercises



Test grids encompass approximately 250 square miles and are designated for outdoor field tests using chemical or biological simulants, TIC/TIMs, and radiological simulants. Test officers will determine grid parameters, sampling positions, meteorological instrumentation, CB cloud tracking systems, referee equipment, and data collection methods as per customer test requirements.

Ranges may include portions of test grids but also encompass mountainous areas on the northeastern and southeastern edges of DPG and Granite Mountain at the center of the installation. Direct, indirect, or live fire activities may occur within training ranges. Impact areas are sections designated for testing or training where artillery, mortar, or missiles are targeted to impact desolate areas of DPG. Radar tracking systems and munitions recovery teams are available on site.

Airspace over DPG, which is part of the Utah Test and Training Range (UTTR), is controlled by agreements between the U.S. Army and U.S. Air Force. DPG has priority for the use of airspace east of Granite Peak and west of Five Mile Hill which is used to support test and training activities. The Air Force has priority of air space west of Granite Peak.

Portable tower with RF links

Test Grids

Test grids are designated areas where outdoor field testing of CB detection systems, individual protective equipment (IPE) and collective protection (ColPro) equipment, and munitions are performed. Grids are constructed as necessary to accommodate the test and data required by a customer's test project. Sampling locations are established to permit fast and efficient collection of air, vapor, and liquid samples. A 17-tower (each 30 meters high) array with four-sector WiFi radio coverage is located throughout the test range. Equipment includes solar/propane generators and 2.4 GHz frequency sector radios (4) to provide low band-width communication to any field test. Fiber optic network drops and associated lines provide a communications link and backbone for real-time data streaming and data delivery to centralized archival systems.

Explosives test at Tower Grid

Dissemination on the test grid

Dugway's test grid is undergoing a comprehensive program to upgrade instrument and network capabilities throughout the grid as well as improvements to Targets R and S, and Tower Grid. This includes remotely-controlled simulant dissemination systems, updated referee instruments, a data network, and a management system to acquire, integrate, analyze, fuse, and visualize data during equipment testing.

Once the upgrade project is complete, test officers and scientists will receive near real-time (NRT) test data analysis and displays via a wireless network; a transportable (safari) test package for remote sites; and the ability to conduct more effective and efficient tests of defense equipment and systems.

Mobile command posts can be stationed at strategic locations throughout the test grid to allow test control personnel to monitor and coordinate field trials, including radio and computer communications with test participants. Customers may observe test activities from either a command post or remotely at the Distributed Test Control Center.

Inside a mobile command post during a test event

Targets R & S – Large, flat terrain grids with an array of roads used to test chemical and biological detection systems with large point, line, and aerial simulant disseminations. Grids include finished roads, meteorology stations, fiber optic lines, wireless communications systems, and CB referee instrumentation. Two, 70-foot fixed disseminator stacks are located at Target S for extended dissemination of vapor clouds, which can be augmented by two more 70-foot mobile dissemination stacks for larger cloud size requirements. Target R has a 12x40-foot fixed-position command post, while Target S features two fixed-position 12X40 command posts. Both Target R and Target S are currently being upgraded to include remotely-controlled simulant dissemination systems, updated referee instruments, real-time data network, and data management systems.

Tower Grid – Tower Grid is laid out with concentric towers, enabling sampling concentrations of airborne liquids, vapors, and particulates in an array at distances up to one kilometer. The grid is used for chemical and biological simulant testing of detection equipment and systems, and is equipped with lighting for night testing. A small, asphalt landing strip near the Tower Grid supports unmanned aircraft sampling and detection of CB simulant aerosols.

Test and training facilities at V-Grid

Aerial Spray Grid – Consists of three separate grids and is used for atmospheric dispersion and ground-level deposition by aircraft and for ground spray trials. The grid features three radial sampling lines with sampling positions located in quarter-mile intervals on radial lines.

All Purpose Grid – This grid is a 1000-square-foot dense array with 50-foot sampling intervals. It is used for aerial spray, biological and chemical defense, smoke and obscurants, and conventional munitions tests.

V-Grid – A circular-shaped grid with an operations area, V-Grid includes meteorological instrumentation positions, and photography and munitions personnel barricades. The grid extends 2000 meters and has a dense array, vertical array, and 11 permanent arcs from 105- to 10,000 meters downwind. Specialized training facilities are also located at V-Grid.

Downwind Grid – Downwind Grid extends 13 miles from its narrowest point (3 miles wide), which encompasses Target S, to a width of 9 miles that overlaps part of West Vertical Grid. It includes a dense array of 2,916 sampling stations at 300-foot intervals. It is used for multiple point source and ground or aerial line source disseminations and features downwind sampling roads at 0.5- and 1.0-mile intervals.

Horizontal Grid – This grid is over one square mile and used to test and evaluate both fixed and dynamic smoke generating sources. Highly specialized instrumentation determines particle sizes, light transmission, and obscuration.

M76 Grid – A small (≈0.75 sq. mi.) grid with a 32-m meteorological tower which can be instrumented with various transmissometers, visible and thermal imagery, particle samplers, and other instruments to characterize visible and infrared obscurants. M76 can be used for smoke and obscurant tests.

West Vertical Grid

Romeo Grid – Constructed to test millimeter wavelength obscurants, the grid features a 400-m radar retroreflector array, visible-infrared transmissometers, cloud dimension cameras, a 32-m meteorological tower, and three 32-m instrumentation towers.

West Vertical Grid – Traditionally used to study area dosage patterns and source strengths to 1.5 miles for small, point-source detonated munitions and particulate disseminations. It consists of eight concentric circles with one moveable sampling array located on the central arc.

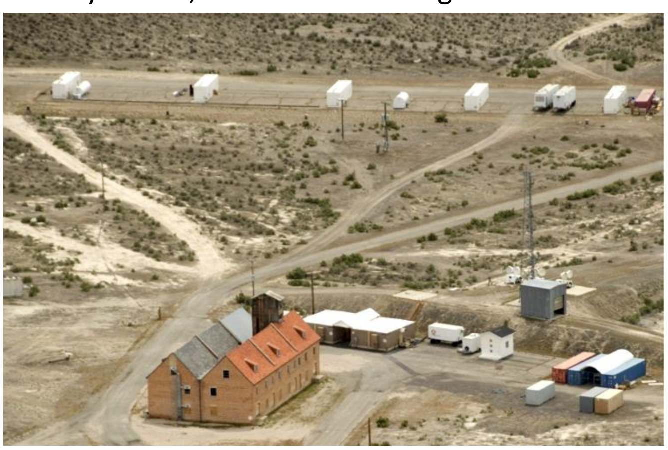
Other test grids and their most common activity include:

- 945 Northwest Grid – Smoke and obscurant tests
- Multiple Impact Grid – Chemical/biological defense, conventional munitions, and obscurant tests
- NASA Grid – Chemical defense, conventional munitions, smoke and obscurant testing
- New Millimeter Wavelength Grid – Conventional munitions, obscurant testing
- Photo Pad 11 – Biological defense, modeling and assessment
- SL-TEST Site – Meteorological experimentation for atmospheric and biosphere sensing studies
- South Ballistic Grid – Conventional munitions, modeling and assessment

Ranges and Impact Areas

Ranges are areas designated for testing or training and impact areas are designated for testing or training where artillery, mortar, or missiles are targeted to impact. All impact areas are marked with warning signs, barriers, or guards. Instrumentation provides in-flight measurements of test munitions. Some ranges or impact areas may coincide with training areas where munitions are fired.

German Village – The primary artillery firing range encompassing over 33,000 acres, this area features velocity radars, smear and tracking camera facilities, firing bunker, ammunition conditioning chambers, survey instrument observation points, commercial electrical power, and underground electrical distribution. Range, deflection, and functioning data can be obtained from 1,000- to 30,000 meters. It can also be used for biological and chemical defense testing along with smoke, obscurant, and illuminant tests.



German Village

White Sage Mortar Range (WSMR) – Located south of the Carr Facility, the WSMR can utilize three azimuths of fire with prepared positions to accommodate both facility mount and ground mount firing. WSMR features velocity radars, smear and tracking camera facilities, survey instrument observation points, and commercial power. Range and deflection data can be obtained from 500 to 13,500 meters down range. The area may also be used for direct mortar firing for the purpose of metal parts recovery, fuze arming, or fuze functioning, plus slow cook-off of various munitions.

White Sage Impact Area – Located at Dugway's southeast corner, the White Sage Impact Area can be used for conventional munitions testing, and smoke, obscurant, and illuminant testing.

Wig Mountain Impact Area – Wig Mountain is located along Dugway's northern border and is used primarily for training troops and is available for military artillery training exercises. The Wig Mountain Impact Area extends approximately 170 square miles west from Wig Mountain through mud flat areas along the DPG northern border.

Wig Range – Located west of the Wig Mountains, this general range area is utilized for artillery observation and small arms live fire training.

West Granite Impact Area – Located west of Granite Mountain, this area is an artillery, mortar, and obscurant range and includes full recovery of projectiles. The area has prepared positions to accommodate all types of artillery, mortar, tanks, and smoke obscurant munitions. Slow cook-off of munitions can also be performed at West Granite Impact Area.

RG-31 Mine Resistant Ambush Protected Vehicle test on Dugway's mountainous terrain

Dugway Thermal Treatment Facility – Formerly known as the open burn/open detonation (OB/OD) area, the Dugway Thermal Treatment Facility (DTTF) is located approximately 3.5 miles south of the Carr Facility and is used to destroy waste munitions and waste explosives. The DTTF includes an oval-shaped area (approximately 40 acres) for detonations of waste explosives that may be initiated at either ground surface or below grade based on treatment specifications from technical data sheets. The facility also includes three, carbon steel burn pans supported by I-beams and seated on square, 18-inch thick concrete pads. Propellant, Explosive and Pyrotechnic (PEP) wastes are characterized prior to thermal treatment. Following OB treatment, all residual ash is containerized and characterized for disposal; following OD treatment, unexploded ordinance and scrap metal visibly contaminated with residual explosives are retreated to ensure complete destruction.

The Open Detonation/Open Burn Improved (ODOBi) facility was developed to test and characterize shrapnel-producing munitions and energetic materials (up to 30 pounds of net explosive weight) deemed by the DoD as excess, obsolete, or unserviceable. Although the test chamber is no longer in service, the facility with its one-inch thick plate steel instrumentation bunker, command post, and the technical expertise of explosives personnel, remains a viable capability for future test and characterization initiatives.

Radiological Assessment and Detection Pad

Radiological Assessment and Detection Pad (Rad Pad) – A 305-meter diameter test site composed of flat terrain surrounded by a two-foot circular concrete barrier. Originally constructed to simulate a nuclear fallout field to evaluate the shielding potential of military equipment, the facility was partially complete when the Department of the Army discontinued the program and was never used for its intended purpose. Today, the Rad Pad includes a meteorological tower and is used for chemical-biological defense and dynamic testing.

Additional ranges and impact areas available at Dugway include:

- M880 Mortar Range
- Baker Strong Point Target Complete Range
- Granite Peak Impact Area
- Granite Peak Range
- Illumination Test Range
- Juliet Range
- Mine Testing Range
- West Granite Artillery Range (Causeway Artillery Range)

Training Areas

The major ground training areas within DPG are the Cedar Mountain Training Area, Wig Mountain Training Area, White Sage Training Area, and West Granite Peak Training Area.

- Cedar Mountain Training Area is within the Cedar Mountains on Dugway's northeastern border and features several interconnecting roads that are used for truck convoy/ambush scenarios.
- Wig Mountain Training Area is south-southwest of the northern portion of the Cedar Mountain Training Area and is east/northeast of the Wig Mountain Impact Area. This training area includes a series of raid sites and associated firing fans, which have been designated and constructed for training of military troops.
- White Sage Training Area includes two noncontiguous areas to the north and northwest of the White Sage Impact Area. The White Sage Training Area is used primarily for artillery and Combat Service Support field operations.
- West Granite Peak Training Area, also known as the Causeway, is located approximately 25 miles west of Ditto, south of Goodyear Road, and west of Granite Peak. This training area is used primarily for artillery and Combat Services Support operations. The area includes velocity radar, smear and tracking camera facilities, firing bunker, ammunition conditioning chamber, and survey instrument observation points.

Training maneuvers at Dugway Proving Ground

See **Specialized Test and Training Facilities/Programs** for more information on training facilities and programs.

Range Control

Range Support, Control, and Scheduling

The Dugway Range Support Branch maintains the DPG test grids and range facilities, which includes providing climate-controlled control rooms, movement of test fixtures and customer equipment to and from test sites, scheduling test range facilities, and preparing cost estimates and completion timelines. The branch supplies portable generators for electrical supply in remote locations, construction expertise for customer test fixtures and facilities, soil excavation, and heavy lifting services up to 40 tons.

Range Control is the designated range control authority which implements and administers functions directly related to the safe and efficient use of all test range facilities. Range Control functions include: range control operations and control of range privileges; establishing and deconflicting asset priorities; conducting clearance inspection of grids, before, during, and after tests; assurance of safe training and regulatory adherence; publishing range regulations; and maintaining and updating historical surface and airspace maps/overlays, files, and other documents.

The range control scheduler is the interface between the Dugway range facility management and customers. The range control scheduler is responsible for final approval of requests for range usage, including scheduling resources, manpower, equipment, maintenance, maneuver areas, grids, facilities and air space. The scheduler is also responsible for resolving safety, scheduling, and environmental conflicts.

Mobile command post

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Dugway Test Grids – Preview the Future

The Test Grid and Safari Instrumentation (TGSI) upgrade project will provide modern, accurate and reliable chemical-biological referee instrumentation (e.g., point detection, lidar, chemical cloud tracking systems, vapor and aerosol analyzers, aerosol particle sizers, etc.), data collection, and dissemination equipment to Target R, Target S, and Tower Grid, as well as mobile test equipment for safari to any point on the test grid.

The TGSI upgrade will improve current data collection and management capabilities across the test grid. When completed, test officers will be able to collect, analyze, and visualize test data in real- or near-real time in support of chemical vapor or biological aerosol field testing.

New instrumentation and test equipment includes:

- An IEEE 802.11g mesh radio network
- Ten 1 Gb/s five-kilometer point-to-point links on an 80 GHz licensed radio frequency
- Upgraded Chemical Cloud Tracking System (CCTS) passive standoff infrared detectors
- Sammi® graphics software and display map application to monitor chemical vapor tomography processing in real-time
- 27, 10-meter instrument towers on portable trailers, two 30-meter WiFi tower trailers, and one 30-meter meteorology instrumentation tower trailer
- 30 portable power trailer systems providing 3 kW of clean (propane) AC/DC power
- Nine Micronair AU9200 agricultural sprayer dissemination systems integrated with microcontrollers, sensors, and network interface
- 11 relocatable command post (CP) that includes client workstations to facilitate real-time data viewing, grid status monitoring, and equipment command and control
- 26 Common Network Interface (CNI) remote data relay-data recorders to support integration and field testing on chemical point detection systems
- Fiber optics system to 17 towers with exclusive-use 3.5 GHz WiFi across the test grid to upgrade initial wireless data capabilities
- Test Grid Operation Center to be used for local data storage, test analysis, and data fusion and visualization

Micronair agricultural sprayers

Section 4

Biological Defense

Lothar Saloman Life Sciences Test Facility

Biological Defense Overview

> *"The ability of terrorists and other non-state actors to develop and use (biological) weapons is growing…there are warning signs and they are too serious to ignore. Terrorist groups have made it known they want to acquire and use these weapons."* - **U.S. Secretary of State Hillary Clinton, speaking at the Review Conference of Biological and Toxin Weapons, Geneva, Switzerland, December 7, 2011**.

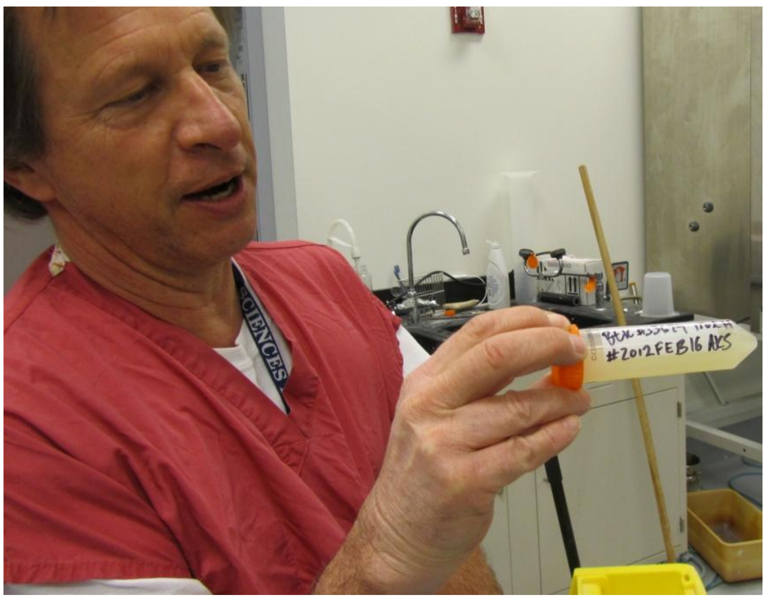
The Life Sciences Division at U.S Army Dugway Proving Ground (DPG) is at the forefront in support of key Department of Homeland Security (DHS) and Department of Defense (DoD) strategic initiatives to protect warfighters and civilians from biological threats, whether it be natural, accidental, or deliberate in nature. These initiatives include: biosurveillance, outbreak recognition and avoidance, pathogen characterization, and medical countermeasures.
Life Sciences features a robust technology base with biosafety level 1, 2, and 3 (BSL-1, 2 and 3) laboratories, environmentally-controlled test chambers, state-of-the-art instrumentation, and a highly-trained and dedicated staff to support developmental and operational test and evaluation (T&E) programs of biological defense systems.

The experienced technical and administrative staff represents disciplines of aerobiology, bacteriology, biometeorology, biochemistry, chemistry, immunology, microbiology, molecular biology, and mycology. Division personnel also support U.S. allies and the international biological community, having exchange agreements with Canada, the United Kingdom, Australia, Japan, and Norway.

The Life Sciences Test Facility (LSTF) is the only DoD facility certified to test developmental equipment and systems with aerosolized BSL-3 agents, such as viruses, bacteria, and biological toxins. The LSTF is the only DoD sentinel laboratory in the western United States approved for receipt of unknown agents in the event of high-priority national need. DPG is the antigen repository for the Critical Reagents Program and has received ISO 17025 and 34:2009 accreditation to produce Biological Certified Reference Materials from The American Association for Laboratory Accreditation.

Scientists, microbiologists, test officers, and technicians conduct T&E with live biological agents and simulants within the LSTF and on the West Desert Test Center (WDTC) grid. Unique capabilities include:

- Biological point and standoff detector T&E
- Whole Systems Live Agent Testing (WSLAT)
- Bioaerosol challenges with live agent and simulants
- Microbiological assays and high-capacity analysis
- Production of bacteria, viruses, biological select agents and toxins (BSAT)
- Production of agent-like organisms (ALO) and simulants
- Methodology development
- Decontamination assessments



Test officers are the primary customer point-of-contact (POC) and have overall responsibility for test planning, scheduling, implementation, financial management, and reporting test results. The test officer assembles a cross-functional team for each test program to tap the expertise of scientific and technical experts from various WDTC divisions.

The WDTC has the inimitable capability to develop methodologies for biological T&E for new or future technologies. If a customer requests a test program that is beyond current capabilities, test officers, scientists, engineers, and microbiologists can develop new test methods and programs to fulfill the requirements.

Biological test challenge material can be disseminated in aerosol, liquid, or powder form in controlled test environments or in field testing. The following tables list some controlled biological agents and simulants that are produced by Life Sciences staff and disseminated during tests: (Note: List is not all-inclusive)

Class	Species	Name
Bacteria	*B. anthracis*	*Bacillus anthracis*
Bacteria	*B. melitensis*	*Brucella melitensis*
Bacteria	*C. burnetii*	*Coxiella burnetii*
Bacteria	*F. tularensis*	*Francisella tularensis*
Bacteria	*R. prowazekii*	*Rickettsia prowazekii*
Bacteria	*Y. pestis*	*Yersinia pestis*
Toxin		Abrin
Toxin		Botulinum toxins
Toxin		Ricin
Toxin		T-2 mycotoxin

Class	Symbol	Name
Virus	EEE	Eastern equine encephalitis
Virus	MoxV	Monkeypox
Virus	VEE	Venezuelan equine encephalitis
ALO	BaS	*Bacillus anthracis* Sterne
ALO	YpK	*Yersinia pestis* KIM
Simulant	BG	*Bacillus atrophaeus*
Simulant	Bt	*Bacillus thuringiensis*
Simulant	EH	*Erwinia herbicola*
Simulant	MS2	Male-specific bacteriophage type 2
Simulant	OV	Ovalbumin

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Biological Testing and Evaluation

> *"There are three primary means of delivering a bioweapon: putting it in food or water, using vectors (such as fleas, ticks, or infected humans), or pumping it into the air (aerosolization). All of these approaches are possible, but the most effective method is aerosol release."* – **The Bipartisan WMD Terrorism Research Center's Bio-Response Report Card, 21st Century Biological Threats, October 2011.**

Biological Testing Overview

The Aerosol Technology Branch is the U.S. Army's technical leader for developmental and operational testing of biological detector components and systems using aerosolized biological agents and simulants produced within the Life Sciences Test Facility (LSTF). Aerosol branch staff also provides support for WDTC decontamination programs and collective protection systems tests.

Test officers, scientists, microbiologists, and technicians utilize LSTF biosafety laboratories, custom-built test fixtures and chambers, and outdoor test grids for technology development and evaluation, product acceptance tests, product verification tests, and technology assessment and selection tests.

The Aerosol Branch has recently acquired the facilities and expertise to determine the efficacy of individual water purification systems (IWPS) to be tested prior to deployment and use in the field by the warfighter. See **Individual Water Purification System Testing** for additional information.

Test Planning and Staffing

Test officers and cross-functional test teams meet with customers to develop test and data collection plans. The team identifies which functional performance characteristics will be evaluated, the number of samples and replicates to be collected, which simulants or characterization of agent will be used, referee and auxiliary equipment required, post-test analysis requirements, and personnel. The test plan may also include subtests or pilot tests to be performed.

A test team may include:

- The test officer who has overall responsibility for a test, including supervising test personnel and ensuring compliance with safety and security guidelines.
- Microbiologists and technicians who conduct test activities, including challenging systems with biological agents and simulants, and performing and recording system maintenance.
- Sample preparers who produce and deliver biological agents and simulants to operators and to PCR technicians for QA/QC analysis, as well as preparing weekly stock solutions and daily system-challenge dilutions.
- PCR technicians conduct real-time quantitative polymerase chain reaction (qPCR) analysis of daily system-challenge dilutions during the analytical subsystem tests and system characterizations tests; the technicians also conduct agent acceptance QA/QC analysis and archive samples.
- Data technicians collect and archive all test officer log information.

- Data analysts collect and archive electronic system files, paper logs, production batch records, QA/QC data, and PCR data generated during a test. Data analysts also track and QC raw data and provide data reduction.
- Data scientists generate performance curves and determine working limit of detection (WLOD) concentration values. Performance curves illustrate the minimum, maximum, and average probability of detection of live or inactivated agent.

Test criteria typically includes the following: 1) all reagents used must pass acceptance testing; 2) all organism strains used in challenge materials must be pure and have the correct genotype; 3) all working challenge material stocks must be uncontaminated and all genetic markers must be present at the start and end of testing; 4) each diluted challenge sample must be uncontaminated and all genetic markers must be present; and 5) each disseminated challenge must be uncontaminated and all genetic markers must be present.

Detector Laboratory Tests

Microbiologists perform small-scale detector tests in BSL-2 laboratories using samples of inactivated agent-like organisms (ALO), various concentrations of biological agent simulant, and battlefield interferents (e.g., burning vegetation, burning diesel fuel) that provides a customer with preliminary sets of data on a unit's response to biological simulants, identification algorithms, false positive rate, and durability.

A Technology Readiness Evaluation (TRE) allows a customer to test, modify, and calibrate a detector's capabilities prior to further developmental. Lab testing provides early analysis of a system's: limits of identification, simultaneous detections, analysis throughput time, technology functionality, and operational readiness.

Test setup inside Aerosol Simulant Exposure Chamber

Test and QA/QC samples are collected and assayed using electrochemiluminescence (ECL) or real-time qPCR. The instruments are used to quantify the number of colony forming units per milliliter (cfu/mL) for bacteria, plaque forming units per mL (pfu/mL) for viruses, or nanograms per mL (ng/mL) for toxins.

Detector Chamber Tests

Characterization and advanced functional tests are conducted within BSL-2 and BSL-3 custom-built fixtures and chambers within the LSTF. The Aerosol Simulant Exposure Chambers (ASEC) are large, environmentally-controlled (temperature and relative humidity) BSL-2 facilities that allow dissemination of live biological simulants, inactivated ALOs, and killed biological simulant, to test detector systems. The ASEC can be configured for both near-static and dynamic tests. In the near-static configuration, chamber airflow is set to a minimum of 50 cfm to maintain negative air pressure while auxiliary fans within the chamber are used to mix the aerosol.

The ASEC has been used to conduct detection system leak tests and to contaminate equipment and materials with simulants to determine the ability of a system to meet Army survivability requirements following decontamination, including functional capabilities. See **Aerosol Simulant Exposure Chamber (ASEC)** for a system description.

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The Containment Aerosol Chamber (CAC) is an environmentally-controlled BSL-3 fixture with half-suits and glove ports where technicians disseminate live biological agents and simulants for signature detection and identification sensitivity tests. The detector challenge chamber (DCC) is a 1 m^3 glove box constructed of half-inch Plexiglas® where test items are placed and exposed to aerosols. The CAC is equipped with triple high-efficiency particulate air (HEPA) filters and compressed air, which allows aerosolization within the DCC to near-zero background particulate levels. See **Containment Aerosol Chamber (CAC)** for additional information.

The Life Sciences Division is nearing completion of a new Whole System Live Agent Testing (WSLAT) Full System Chamber to provide a large-scale test capability for the Joint Biological Point Detection System (JBPDS) and other biological aerosol detection systems. For a system description, see **Whole System Live Agent Full System Chamber – Preview the Future**.

Chamber Aerosol Dissemination

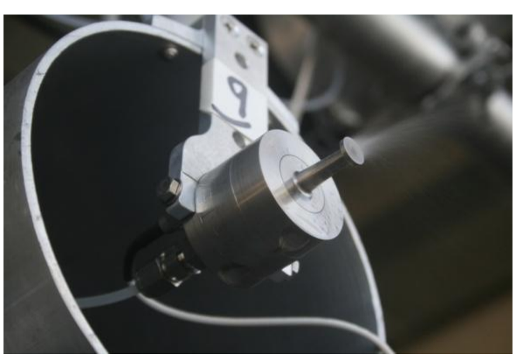
Containment Aerosol Chamber

Ultrasonic atomizing nozzles (Sono-Tek Corporation) are the primary aerosol generation system used in ASEC/CAC test programs. Liquid slurries are atomized into a fine mist spray using high-frequency sound vibrations; piezoelectric transducers convert electrical input into mechanical vibrations creating capillary waves in the liquid when introduced into the nozzle. The near mono-dispersed droplets dry into particles generating a desired number median aerodynamic diameter (NMAD) for each aerosol challenge.

An infusion syringe pump is typically used to deliver the particle suspension to the nozzle because of its accuracy and adjustable delivery rate. An agitator, such as a rocker plate with Teflon® balls loaded into the syringe, prevents settlement of the slurry during delivery to the nozzle. By adjusting the liquid slurry composition, dried-down particles can be obtained with pre-selected NMADs ranging from 1.5 to 6.0 µm (±0.5 µm). Aerosol characteristics recorded for each trial includes NMAD and mass median aerodynamic diameter (MMAD).

The Sono-Tek nozzles produce aerosol concentrations of live or inactivated organisms and simulants ranging from approximately 10 to 37,800 (ASEC) and approximately 5 to 12,500 (CAC) agent-containing particles per liter of air (ACPLA). Target concentrations generally range from 100 to 500 ACPLA. Dissemination slurry concentrations are calculated from stock concentrations in cfu/mL, pfu/mL, ng/mL, or genomic equivalents (GE)/mL.

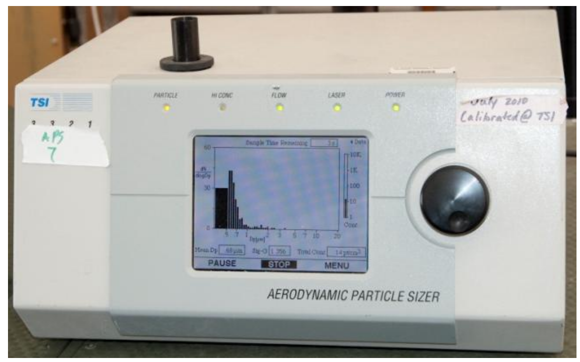
A system may be challenged with biological agents to determine the performance identification threshold at which a 50 percent probability of identification (PID50) is achieved and a limit of detection (LOD) at which a 50 percent probability of detection (PD50) is achieved for each agent. Challenge concentrations can be disseminated below detection threshold, above detection threshold (but below the identification threshold), and above both the detection and identification thresholds. Aerosol cloud time may range from 5 to 30 minutes within a chamber, as per test requirements.



Chamber Referee Instrumentation

Test officers deploy a variety of referee instruments to collect test samples during trials within the ASEC and CAC. The four primary sample collection systems used are: XMX High-Volume Aerosol Multi-Sample Collector (XMX/2L-102) (Dycor Technologies Ltd.); Aerodynamic Particle Sizer® (APS™) and Ultraviolet Aerodynamic Particle Sizer® (UV-APS™) (TSI Incorporated); slit-to-agar (STA) samplers (New Brunswick Scientific and Mattson-Garvin Company), and all-glass impingers (AGI).

The XMX/2L-102, an aerosol separator, sample preparation, and high mass flow concentrator system, is the primary sample collection system for bacteria and toxin simulants and serves as a secondary collection system for *Bacillus atrophaeus* (BG). The system is capable of collecting large aerosol concentrations in the respirable range and impinged in various collection fluids, including phosphate-buffer saline (PBS), distilled deionized (DI) water, or other buffer solution. The sample carousel has a capacity of 102 samples, and sample times can be adjusted from 10 seconds to 10 minutes. The intake flow rate is approximately 600 standard liters/minute (SLPM) (±25 SLPM).



The APS™ spectrometer is used to monitor particle size and concentration of particles per liter for environments with minimal background particles. The APS™ provides real-time aerodynamic measurements of particles from 0.5 to 20 µm and measures light-scattering intensity from 0.37 to 20 µm. The UV-APS™ spectrometer uses a time-of-flight signal to measure aerodynamic size and scattered-light intensity particles between 0.5 and 15 µm. UV-APS™ also measures the fluorescence properties of individual particles, utilizing a pulsed-ultraviolet laser, distinguishing the biological aerosol particles from inanimate materials. Both APS™ systems feature programmable sampling times from 1 second to 18 hours. APS™ systems can operate on Aerosol Instrument Manager (AIM®), APS™ Reader, and CBNET 5.16 software

Slit-to-agar is the primary aerosol sampler for viable spore-forming bacteria. The system uses a vacuum source to draw air through a 0.152 mm slit at 1 cubic foot/minute and impinging the particles on an agar surface below the slit; the agar is contained in a 150 mm diameter culture plate which is rotated by a synchronous drive motor. After incubation (48 to 72 hours) of the culture plate, colonies can be counted and evaluated. The STA sampling range is between 0 and 300 viable particles per liter of air.

All-glass impingers collect airborne particles in a precision glass tube (shaped like a human windpipe) that allows airflow to be drawn into the tube by a vacuum source. AGIs use liquid collection fluids, including PBS, DI water, or other buffer solution. Sampling times may range from 2 to 5 minutes and may be run in sequence using software. AGIs are used to collect vegetative bacteria, viruses, toxins, and bacterial, viral, and toxic simulants.

An alternative dissemination system has been used to introduce non-aerosol simulants into a detection system. The Ink Jet Aerosol Generator (IJAG) provides direct injection of aerosolized killed agent particles directly into a system's inlets, reference system, and referee system. The IJAG enables testing biodetection instruments with concentrations of challenge particles from <1 particle/sec to approximately 500 particles/sec. The IJAG cartridge produces primary droplets of about 50 µm and residue particle diameters of 2 to 10 µm; slurry concentration ranges from 0.006% to 0.8%.

Whole System Live Agent Testing Full System Chamber – Preview the Future

Installation of the Whole System Live Agent Testing (WSLAT) Full System Chamber within the renovated Baker Laboratory is expected to be completed in the summer of 2012 marking an almost decade-long effort to provide a large-scale test capability for the Joint Biological Point Detection System (JBPDS) and other biological aerosol detection systems. Construction of the Biosafety Level 3 (BSL-3) containment facility that houses the WSLAT chamber has been completed.

The JBPDS is designed to limit the effects of biological agent attacks by providing automatic point-detection, alarm, identification, and sampling of up to 10 biological agents simultaneously in less than 15 minutes. Prior correlation testing of the JBPDS (strung-out versions with threat-representative live agents and simulants) has occurred within the Containment Aerosol Chamber (CAC), Aerosol Simulant Exposure Chamber (ASEC), and the Ambient Breeze Tunnel (ABT). Once complete, the WSLAT chamber will allow simultaneous bioaerosol testing of two JBPDS units side-by-side, as well as testing of other large detection systems.

WSLAT chamber under construction (above) and rail system (right)

The 200-cubic-meter, stainless steel chamber will allow scientists and test officers to control temperature (10-40°C), relative humidity (15-60% ±10% RH), and wind speed control (1-6 meters/second) to simulate various climatic conditions. The chamber is designed to have the capability of generating threat-representative aerosolized wet and dry biological warfare agents or simulant preparations of bacterial spores, vegetative bacteria, viruses, and toxins. The aerosol generation system is expected to deliver near-monodisperse particle sizes between 2.0 and 6.0 µm with a standard deviation of ±2.5 µm; aerosol concentrations are expected to range between 20 (±10) and 1000 (±250) agent-containing particles per liter of air (ACPLA).

Upon the completion of WSLAT chamber verification and validation, scientists, microbiologists, test officers, and staff from the WDTC and Joint Project Manager for Nuclear, Biological and Chemical Contamination Avoidance (JPM NBC CA) can complete WSLAT program objectives, including:

- Collection of JBPDS operational effectiveness data
- Validation of referee and dissemination protocols for test facilities
- Data collection requirements and validation of data collection processes
- Data collection to support agent-to-simulant correlations
- Creation and validation of dissemination protocols for threat-representative challenge materials
- Test results that are repeatable and consistent

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Detector Tunnel Tests


Ambient Breeze Tunnel

The Joint Ambient Breeze Tunnel (JABT) and the Ambient Breeze Tunnel (ABT) provide a “test bridge” between chamber and outdoor field testing. The tunnels are BSL-1 facilities that allow test officers to deliver and control homogeneous biological aerosols under ambient temperature and humidity conditions to evaluate point and standoff detectors and referee systems without weather interference.

The ≈168-meter JABT allows dissemination of biological simulant clouds and interferents between 20 and 100 meters in length that can be transported through the tunnel at speeds ranging from 0.2 to 6.0 meters per second. The JABT can be configured for both point detectors (west door open, east door closed and interior and exterior baffles in use) and standoff detectors (end doors open with external side baffles only). The JABT is also used for simulant cloud characterization, instrument calibration, and airflow mapping of collective protection systems. For more information, see **Joint Ambient Breeze Tunnel (JABT)**.

The 46-meter ABT has an arching roof and is open on both ends for testing and evaluating detection systems and referee equipment. The dissemination system can produce simulant target concentrations ranging from 0 to 300 ACPLA with particle sizes ranging from 2.0 to 6.0 µm. Blower fans can generate wind speeds to 5 mph with aerosol cloud concentrations typically maintained for 5 minutes. See **Ambient Breeze Tunnel (ABT)** for a system description.

The Active Standoff Chamber (ASC) is another large-scale facility where aerosol clouds of biological simulant may be generated and controlled. The 131-meter ASC is a temperature-controlled environment where standoff detector tests can be conducted between 40° and 95°F. Air curtains provide semi-permeable barriers at both ends of the chamber. The dissemination system can produce liquid aerosol particles from 1 to 500 µm with a concentration of 500 to 10,000 ppL. Dry aerosols can be disseminated between 1 and 30 µm at concentrations ranging from 300 to 100,000 ppL. See **Active Standoff Chamber (ASC)** for additional information.


JBPDS test setup inside Ambient Breeze Tunnel

Tunnel Dissemination Systems

A variety of dissemination systems may be deployed within the JABT and ABT, including permanent systems or portable systems that may be configured for individual trials. The JABT features a dissemination gate and overhead, four-zone Sono-Tek nozzle array, while dissemination carts provide maneuverability for precision set-up of aerosol cloud generation.

Portable dissemination system

Portable liquid and dry dissemination systems may be operated for specific tests to replicate an attack (e.g., covert backpack attack), including electric Micronair sprayers and E2 sprayers, Skil® blowers, and puff disseminators. The electric Micronair uses simulant slurry to release up to two liters per minute; a release of 200 to 400 mL in a tunnel results in a concentration of 5,000 to 10,000 particles per liter. A dry powder simulant release of 5 to 10 grams using a Skil® blower creates in a concentration of 5,000 to 20,000 particles per liter inside a tunnel.

Interferents may be incorporated into tests within the tunnels, including: road dust, diesel exhaust, burning vegetation, wood, and rubber, fog oil, and colored smoke grenades.

Tunnel Sampling and Referee Instrumentation

Sampling and referee instrumentation are typically connected to custom-built towers and positioned downwind from the tunnel dissemination systems. A MYTOS laser-diffraction system (Sympatec GmbH) or a phase-Doppler laser velocimeter (Battelle Memorial Institute) can measure particle and droplet size and velocity at the discharge point of sprayers.

Aerodynamic Particle Sizers® are real-time referee systems that monitor background aerosol concentrations as well as simulant aerosol concentrations and particle size distributions from 0.5 to 20 µm. Particle samples are collected from aerosol clouds using in-line and filter impaction technologies, with sample analysis by scanning electron microscope (SEM), providing an alternative method to determining particle size distributions.

Test officers may also use slit-to-agar samplers, all-glass impingers, and XMX/2L-102 aerosol sample collectors as referee instrumentation. A Portable Aerosol Spectrometer (PAS) (Grimm Technologies) provides single particle count and size classification in real time. The PAS measures particles from 0.25 to 32 µm (from 1 to 2,000,000 particles/liter) at a sample flow rate of 1.2 liter/min. An Aspect Aerosol Size and Shape Analyser (Bristol Industrial & Research Associates Ltd) may be used to simultaneously measure the shape of airborne particles in real time, as well as size and total particle concentration. Samplers at all locations can be controlled by a central sampling controller which regulates the start of sampling and duration time.

Tunnel wind speed, wind direction, temperature, and relative humidity (RH) are measured by tripod-mounted Portable Weather Information Display Systems (PWIDS) or sonic anemometers. Water-sensitive witness cards may be used to characterize deposited droplet sizes.

Referee light detection and ranging (lidar) systems, such as West Desert Lidar (WDL), Raman-shifted Eye-safe Aerosol Lidar (REAL), and laser-induced fluorescence (LIF) systems, may be positioned approximately 600 to 1200 meters outside the end of a tunnel and lased into the interior. Lidar measurements may include: simulant or interferent used, cloud characterization, and start/stop times of dissemination. See **Light Detection and Ranging Systems** for additional information.

Detector Tunnel Test Trials

Objectives of tunnel test trials are itemized within a detailed test plan developed by the test officer and customer, and include the number of daytime and nighttime trials, simulant selection, referee sampling and instrumentation requirements, data collection and reporting methods, and photographic requirements.

A series of trials within the JABT/ABT may be developed to establish the detection sensitivity of a system when challenged with biological simulants and interferents in a controlled environment. The tunnels allow demonstrations of detector system operations during open-air releases in a dry environment and to determine the likelihood of a system to generate false alarms in the absence of biological releases.

Test setup for Joint Biological Point Detection System (JBPDS) inside the Ambient Breeze Tunnel

Tests are designed to assess a candidate detection system's capabilities such as: evaluating the benchmark sensitivity of the selected detection technology to respond to various biological simulants and interferents; producing false positive results; discriminating between biological clouds in daylight and during nighttime; ability to operate continuously for a designated time period; performing near real-time detection of biological clouds; and the ability to start up and become fully functional in less than 30 minutes.

Candidate standoff detection systems are typically set up outside the JABT at approximately 1.2 km and positioned to lase through the east opening of the JABT. WDTC referee lidar systems are typically positioned side-by-side to simultaneously record the controlled releases of biological simulants and interferents and to collect signature and performance data.

Additional biological defense projects conducted inside the JABT/ABT have included aerosol modeling, simulant variability studies, component tests for the Stryker Nuclear, Biological, and Chemical Reconnaissance Vehicle (NBCRV), and developer technology demonstrations.

Detector Field Tests

Dugway's 250-square-mile test grid of arid, flat terrain allows for detector field testing under operationally realistic conditions to evaluate a system's effectiveness, functionality, and survivability for future use by U.S. and allied troops. Individual field trials may run over several weeks, as described in the test plan, and may include both day and night testing.

Developmental and operational field tests may be conducted within a single, instrumented test grid (e.g., Target S, West Vertical Grid) that allows aerosol, liquid, and powder disseminations to be conducted without restrictions to wind direction, or may encompass multiple test grids throughout the range for multi-service operational tests. Detector systems may be tested in fixed locations or attached to vehicles, such as the Stryker NBCRV, which travel on predetermined routes. A wireless network allows data to be captured from remote locations. See **Dugway Test Grids and Ranges** for addition information.

Sampling array for field Joint Biological Tactical Detection System (JBTDS) test

Standoff detector systems under test (SUT) are positioned alongside lidar referee systems and oriented so that they lase in the same direction; systems will lase simultaneously during open-air releases of simulant at varying distances. Test objectives may include: technology evaluation in response to various simulants and interferents; daytime/nighttime biological cloud discrimination; length of continuous operation; near-real time cloud detection; number of false positive results; and time for SUT to become fully functional. Simulant clouds are generated perpendicular to the SUT laser path to ensure a target concentration of simulant passes through the laser path.

Eleven biological simulants are approved for outdoor release on the Dugway test grids, such as: *Bacillus atrophaeus* (BG), *Bacillus thuringiensis* (Bt), *Erwinia herbicola* (EH), ovalbumin, Venezuelan equine encephalitis (VEE) killed (TC-83), and *Yersinia pestis* KIM (YpK). Interferents (e.g., burning vegetation, fog oil, diesel exhaust, road dust) may be released individually or simultaneously to allow a system to detect biological simulants in the presence of interferents.

Biological simulants may be disseminated by stationary or mobile agricultural sprayers, backpack spray systems, blower systems, simulated projectile airburst launchers (SPAL), and air cannons. Field test dissemination systems include:

- Micronair sprayers – Disseminate 500 mL/min of biological simulant slurry for 10 minutes
- Skil® blowers – Typically disseminate 100 to 500 g of dry powder simulant
- Agricultural sprayer, vehicle mounted – Disseminate 3 lbs/min dry powder
- SPAL – Used to replicate a rocket attack, can release 25 to 100 g of dry powder up to 25 feet, with a typical release of 10 SPALs at 50 g per SPAL
- Air cannon – Releases up to 150 g of dry powder creating a 40-foot cloud

Dissemination systems may be positioned up to 4 km from nearest detector, as per test requirements. See **Field Dissemination Systems** for more information on dissemination methods.

Laser Induced Fluoresce (LIF) Lidar

Threat-representative biological clouds are released to provide detection opportunities for multiple detector SUTs throughout the test grid(s). LIF, REAL, and WDL lidar systems detect, track, and measure cloud location and concentration, and transmit data to a portable command post (CP). All lidar systems produce three-dimensional data from aerosol clouds through raster scanning. See **Light Detection and Ranging Systems** for a description of each system.

Test officers can deploy up to 10 portable towers (truck-bed mounted) to attach sampling and referee instrumentation, including APS™, UV-APS™, STA, PAS, and AGI systems. Sample analysis is completed with ECL or PCR assay. The High Performance Asynchronous Multiplexing System (HPAMS) is a system controller that collects data from various sensors, time stamps the data, formats the data, then transmits the data to a CP or data collection system.

A suite of meteorological instrumentation is incorporated into field trials as aerosol-cloud concentrations fluctuate over space and time under a variety of meteorological conditions. Fixed and mobile 32-meter meteorological towers contain temperature and RH probes, plus sonic anemometers to monitor wind speed and direction. PWIDS on 2 m towers provide temperature and RH data at 10-second intervals.

Heat flux measurement stations measure net radiation, sensible and latent heat flux, ground heat flux, and shortwave and longwave solar radiation. Radiosondes can be used to measure air pressure, altitude, geographic position, temperature, RH, and wind speed/direction. Frequency-Modulated Continuous Wave (FM/CW) or WindTracer® Doppler Lidar measure near ground-level wind fields.

WindTracer® Doppler Lidar

Meteorological data collected near ground level and at elevated monitoring location enable dispersion models to predict cloud behavior as accurately as possible.

Meteorological data collected may include: horizontal and vertical extent of aerosol cloud as a function of time; two-dimensional area of cloud; maximum concentration and location of cloud centroid in a 2D plane; height of inversion layer; near-surface wind speed and direction, temperature, and RH as a function of time; wind speed and direction, temperature, RH, and turbulence measurements at fixed heights (32 m); vertical profiles of cloud height, pressure, wind speed and direction; and net radiation, soil surface heat flux, solar shortwave radiation, and solar longwave radiation.

On-site meteorologists monitor local Doppler radar systems to provide current forecast information to test officers. See **Weather Forecast Systems** and **Meteorological Instrumentation** for additional information. High-definition still and video documentation is available for all biological test programs.

Detector Test Data Collection

Data Sciences Division staff ensures efficient and effective test data acquisition and measurements with planning-stage involvement to help define customer requirements and objectives, to strategize how to best meet those objectives, and to establish automated data collection and QA/QC processes for quicker responses. Data reduction and analysis services are provided by statisticians and analysts.

The Test Mission Support System (TMSS) is the WDTC network information technology system for test data collection, transfer, and storage. The test grid wireless infrastructure includes Wi-Fi towers that cover the grid with a wireless network and allows test equipment to connect and operate as a large outdoor laboratory. The Mobile Image Processing System (MIPS) is a photonics data processing capability that supports field and chamber test programs. The photonics Image Data Processing Lab has a complete suite of image processing software and analysis hardware tools and applications, both COTS and custom-developed systems and applications, to provide complete analysis of SUTs. See **Test Data Acquisition and Management** and **Test Event Imaging** for additional information.

Test and referee data may also be collected on digital video discs (DVD) and provided to an independent party, such as the Johns Hopkins University Applied Physics Laboratory (JHU/APL) or the Edgewood Chemical Biological Center (ECBC) Technology Readiness Assessment (TRA) group, for evaluation of SUTs. Data collected onto DVDs are also uploaded to TMSS.

A detector test data package may include:

- Trial start/stop times
- Dissemination methods and challenge material
- Dissemination slurry concentration (cfu/mL, pfu/mL, ng/mL, or GE/mL)
- Dissemination feed rates (mL/min) and start/stop times
- Quantity of material released
- Cloud characteristics
- Sample collection start/end times
- Time-stamped APS™/UV-APS™ files
- Temperature and relative humidity
- Meteorological conditions
- ASEC/CAC airflow rates
- Sensor maximum algorithm counts
- Sensor alarm start/stop times
- False positive rate
- Time of identification and results
- Lidar referee data
- Results of ECL or PCR assays
- Detector performance curves
- Reports of incidents (ROI) of detector failures, maintenance issues, or unusual operations
- Photographic or video test documentation

Biological Safari Field Testing

Aerosol Technology Branch scientists, microbiologists, and test officers have the capability of off-site biological testing, analysis and incident response. Test programs can be implemented at other military installations or at a location designated by a customer.

Dugway dissemination systems – Micronair disseminators, air cannons, SPALs, Skil® blowers, portable disseminators with Sono-Tek Ultrasonic atomizing nozzles – may be deployed to meet specific customer requirements. Meteorological instrumentation (PWIDS, weather surveillance Doppler radar, radiosonde systems, FM/CW boundary layer radar), referee equipment (including lidar systems), and sampling systems may also be deployed for a safari test program.

Analytical support can be accommodated with the mobile Biological Laboratory Trailer which provides mobile forensic-level detection of biological materials, including polymerase chain reaction (PCR) equipment for DNA extraction and amplification, and on-site sample analysis of biological agents. The 50-foot trailer has four slide-out sections creating 940 square feet of work space, including biological safety cabinets (BSL-2) and real-time PCR analytical tools. The 50-foot trailer will fit inside the bay of a large Air Force cargo plane for fast deployment or for transport OCONUS.

A master mix lab is a low titer zone that has controlled-access, a lab-grade micro refrigerator and space for a water heater. DNA extraction equipment is located within a medium titer zone and has a full-size laboratory grade freezer, refrigerator, and a BSL-2 safety cabinet. A pass-through area allows sample transfer between isolated titer zones to reduce the possibility of cross-contamination. An airlock provides access into the high titer lab from the common entry area and contains real-time PCR systems, a pyrosequencer, BSL-2 cabinet, incubator, and autoclave.

Quick Facts

Aerosol Technology Branch scientists recently conducted a simulant variability study of the Joint Biological Standoff Detection System (JBSDS II) within the JABT and ASC.

The study identified parameters that contribute to cross-section variability. The material cross section is a measure of efficiency of the light reflected from bioaerosol particle surfaces, a metric used in biological standoff detection.

Scientists evaluated variability caused by differences in simulant growth media, seed stock, fermentor size, method of sporulation, lab-to-lab variability, milling procedures, and aging.

This study was conducted in conjunction with Eglin Air Force Base, Florida.

The biological laboratory trailer has supported high-profile public events for various governmental organizations, including the Department of Homeland Security, and can be available to support a biological incident.

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Microbiological Laboratories, Analytical Capabilities, and Instrumentation

We are fortunate that biological threats have not yet resulted in a catastrophic attack or accidental release in the United States. However, we recognize that: (1) the risk is evolving in unpredictable ways; (2) advances in the enabling technologies will continue to be globally available; and (3) the ability to exploit such advances will become increasingly accessible to those with ill intent as the barriers of technical expertise and monetary costs decline. Accordingly, we cannot be complacent but instead must take action to ensure that advances in the life sciences positively affect people of all nations while we reduce the risks posed by their misuse. – **U.S. National Security Council, National Strategy for Countering Biological Threats, November, 2009**

Microbiology Capabilities Overview

The Life Sciences Division (LSD) is a major U.S. Army focal point to "reduce the risks" by providing full analytical support for West Desert Test Center (WDTC) biological test programs, as well as initiatives of the U.S. Department of Defense (DoD), U.S. Department of Homeland Security (DHS), U.S. Justice Department, and the Center for Disease Control and Prevention (CDC). Dedicated and experienced LSD scientists hold advanced degrees in microbiology, virology, and molecular biology. Scientists and technicians have extensive hands-on experience working with biological agents and agents of biological origin (ABO) for testing, analysis, decontamination programs, and medical countermeasures initiatives.

The laboratories and infrastructure within the Life Science Test Facility (LSTF) provide full bioassay, characterization, and quality analysis of test materials, and quantification of referee samples acquired during biological test events. LSD capabilities include:

- Tissue culture management to support bioassays and monoclonal antibody/virus production
- Molecular assay and analysis of bacteria, viruses, genetic molecules, and proteins
- Full or partial genome sequencing of bacteria and viruses, and antibody-based tests to detect the presence of a biological threat agent
- Immunoassay such as enzyme-linked immunosorbent assays (ELISA) to test for specific antigens or antibodies
- Microbial identification analysis
- Scanning electron microscopy for test sample analysis and biomarker image analysis
- Antigen purification and characterization, through electrophoresis and immunoblot analytical techniques

LSD staff members safely procure, handle, manipulate, store, transport, transfer, and dispose microorganisms, bacteria, viruses, and toxins for tests and analysis in accordance with federal, state, DoD, and Army regulations, and Dugway standard operating procedures. Microbiological testing and research within the LSTF does not exceed biosafety level 3 (BSL-3).

The division provides ABOs, including inactivated ABOs, to many DoD research and development facilities for use in laboratory tests. The LSTF is the only CDC Laboratory Response Network (LRN) sentinel laboratory in the western United States that may receive unknown biological agents.

Future capabilities may include testing on animals because the LSTF's existing laboratories and infrastructure can accommodate proper housing and conduct of mammalian tests.

Biosafety Laboratories

All LSTF operations combine good laboratory practices and techniques, proper safety equipment, and facilities that enable hazardous biological materials to be manipulated safely. Biosafety levels represent the conditions in which an agent or toxin can be handled safely as recommended by the CDC and the National Institute of Health (NIH). The LSTF houses BSL-1, BSL-2, and BSL-3 facilities.

BSL-1 is suitable for work involving well- characterized agents not known to consistently cause disease in immunocompetent adult humans, and present minimal hazard to laboratory personnel and the environment. In BSL-1 laboratories, work is typically conducted on open bench tops using standard microbiological practices. Examples of BSL-1 organisms include: *Bacillus atrophaeus* (BG) and *Bacillus thuringiensis* (BT).

BSL-2 labs build upon BSL-1 and are suitable for work involving agents that pose moderate hazards to personnel and the environment. BSL-2 labs differ from BSL-1 in that: 1) lab personnel have specific training in handling pathogenic agents and are supervised by a scientist competent in handling infectious agents and associated procedures; 2) access to the laboratory is restricted when work is being conducted; and 3) all procedures in which infectious aerosols or splashes may be created are conducted in BSCs or other physical containment equipment. Examples of BSL-2 materials include inactivated irradiated, or vaccine grade: *Bacillus anthracis*, *Francisella tularensis*, *Yersinia pestis*, and toxins such as ricin and staphylococcal enterotoxins. Methods of exposure may include:

- Accidental percutaneous
- Mucous membrane
- Non-intact skin exposures
- Ingestion of infectious materials

The LSTF has 30 BSL-2 labs encompassing over 6,800 square feet of space. In addition to meeting BSL-1 requirements, these BSL-2 laboratories have designated autoclaves to safely render/sterilize any hazardous test materials and restricted access to laboratory space while tests are being conducted.

BSL-3 practices, safety equipment, and facilities are applicable to clinical, diagnostic, teaching, research, or production facilities in which work is done with indigenous or exotic agents that may cause serious and potentially lethal diseases from exposure by inhalation. The LSTF has 3,600 square feet of space dedicated to BSL-3 laboratories which have special engineering and design features, physical containment devices, and separate ventilation systems.

The Life Sciences Division BSL-3 labs meet or exceed all safety, security & accountability containment requirements in accordance with CDC Select Agent Registration requirements and Department of Army Surety requirements to include: additional access controls, non-recirculating airflow, vacuum lines with liquid disinfectant traps or high-efficiency particulate air (HEPA) filters, and decontamination of all waste prior to disposal. BSL-3 examples include: *Brucella abortus*, *Coxiella burnetii*, and Venezuelan equine encephalitis (VEE).

The LSTF has over 50 biological safety cabinets, certified by National Sanitation Standard (NSF) certified technicians, which are combined with engineering controls to enable lab personnel to safely handle infectious etiologic agents and to provide primary containment of any aerosols produced. There are three major classes of cabinets (I, II, and III) and four subclasses of class II cabinets. All class II and III safety cabinets are certified before use, annually, and after repair, relocation, or modification.

Microbiological Analysis and Instrumentation

Microbiologists and technicians prepare, coordinate, and implement comprehensive laboratory tests in support of developmental and operational biological defense programs, biosurveillance, medical countermeasure initiatives, the Critical Reagents Program (CRP), and the CDC.

Principle investigators oversee a broad range of molecular biological tests and investigations, including cloning and expressing recombinant proteins and peptides and creating probes for detection of biological agents.

Test Sample Analysis

Laboratory, chamber, and field test referee samples are obtained from various sample collection systems such as all-glass impingers, slit samplers, and XM2 biological agent samplers and transported to the Assay Lab located within the LSTF.

JEOL JSM-6010LA scanning electron microscope

Referee samples collected during bioaerosol test trials are analyzed with a low-vacuum scanning electron microscope (SEM) (JEOL JSM-6010LA InTouchScope™). The SEM is capable of quantitative and qualitative elemental analysis of spores, vegetative cells, and spore powders with a magnification range of 5x to 300,000x and resolution of 4 nm @ 20 kV.

The Attune® Acoustic Focused Flow Cytometer provides microbiologists with a laser-based detection system to conduct rapid characterization of an entire population of cells. Applications include analyzing proteins expressed by cells (immunophenotyping), quantifying the amount of deoxyribonucleic acid (DNA) in cells, and performing cell counts. The flow cytometer provides real-time quantitative analysis of both active and deactivated aerosol challenges in chamber and field tests and permits accurate sizing of particles in the range of 3 to 40 µm.

Bacterial and Viral Analysis

Bacteria, viruses, and toxic agent test and quality control samples are detected and assayed with a BioVeris M-SERIES® M1M analyzer which utilizes electrochemiluminescence (ECL) technology for immediate confirmation of the presence or absence of biological agents. ECL is a highly-selective process and can detect and analyze agents such as botulinum neurotoxins, staphylococcal enterotoxin B, ricin, *Bacillus anthracis* spores, *Yersinia pestis* F1 antigen, and Venezuelan equine encephalitis (VEE).

Technicians identify bacteria and yeasts with a Sherlock® Microbial Identification System (MIDI, Inc.), which combines Agilent Technologies 6850 Series gas chromatograph (GC) analysis with Agilent ChemStation software and Sherlock® instant libraries. The system analyzes fatty acid methyl esters (FAME) and uses peak naming and pattern recognition algorithms to identify fatty acid sample extracts which allows for strain tracking.

Beckman Coulter Multisizer™ 3 Coulter Counter®

A Beckman Coulter Multisizer™ 3 Coulter Counter® provides accurate particle sizing and counting analysis, including number percentage, volume percentage, mass, and surface area distributions, with an overall sizing range of 0.4 µm to 1,200 µm. Instrument response is not affected by particle color, shape, composition, or refractive index. The Coulter Counter® can detect cell size and volume changes within a few seconds or over several hours.

Genetic Analysis

DNA regulates an organism's development, growth, physical properties, and pathogenic capabilities, and the genome encoded either in the DNA, or for many types of viruses, within the ribonucleic acid (RNA), represents the organism's entire hereditary information. Genomes include both the genes and non-coding sequences of the DNA or RNA.

Dugway microbiologists perform a variety of analytical studies of genetic molecular samples utilizing quantitative polymerase chain reaction (qPCR) technologies and DNA sequencing in support of the nation's biological defense programs. LSD has an extensive library of custom assays which allows for accurate identification and quantification of small samples of select agent or simulant from laboratory or field tests.

Real-Time PCR

PCR amplifies and quantifies DNA sections allowing an organism to be identified based on its genetic fingerprint. Microbiologists perform real-time PCR using customized assays with an Applied Biosystems® 7900HT Fast Real-Time PCR System. A small sample of amplified DNA can be used to positively identify an organism from which the DNA was isolated.

LSD microbiologists have real-time multiplex PCR capabilities for nucleic acid identification and quantification, gene expression, genotyping, and protein ligation assays with an Applied Biosystems® ViiA™ 7 Real-Time PCR System. The high resolution detection system accommodates both standard and fast-cycling 96- and 384-well plates for enhanced fluorescence detection using TaqMan® Array Micro Fluidic Card. The system can detect 1.5-fold changes in target quantities in singleplex reactions.

Applied Biosystems® ViiA™ 7 Real Time PCR System

Scientists prepare assays and develop analytical methods to determine the number of genomic equivalents (GE) for standardized biological test material (SBTM) produced for biological defense testing. The Applied Biosystems® 7900HT Sequence Detection System (SDS) is used to conduct real-time PCR to amplify, detect, and quantify DNA from SBTM prepared for analysis by bead-milling and solvent exchanged on size-exclusion spin columns.

Microbiologists utilize electrophoretic separation systems, such as the Agilent Technologies 2100 Bioanalyzer, for sizing, quantification, and quality control of DNA, RNA, proteins, and cells. Electrophoretic assays are based on gel electrophoresis principles that are transferred to a chip format. The 2100 Bioanalyzer (Agilent Technologies) is a microfluidics-based platform for sizing, quantification, and quality control of DNA, RNA, cells, and proteins. Technicians develop multiplex-detection assays that can simultaneously interrogate samples for a variety of bacteria and viruses. Analytical results are typically delivered within 40 minutes.

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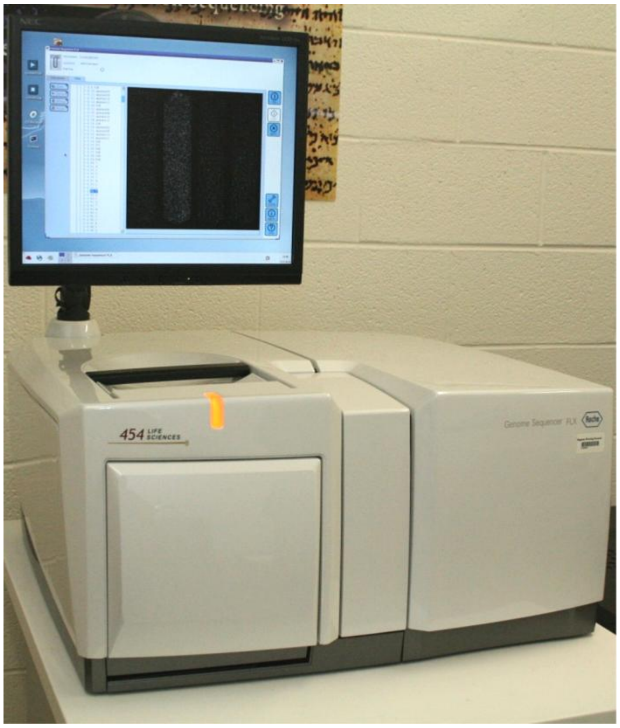
PCR instruments have supported numerous test programs at Dugway, including sample analysis for the Whole System Live Agent Test (WSLAT) program and characterization of the BioWatch Generation-3 (Gen-3) detectors.

DNA Sequencing and Analysis

WDTC microbiologists perform DNA sequencing to determine the order of nucleotide bases (adenine, guanine, cytosine, and thymine) in a molecule of DNA. Sequences within DNA vary between organisms and the presence of a specific DNA sequence may be used to identify the organism. DNA sequencing allows WDTC scientists to determine which stretches of DNA contain genes and to analyze the genes for changes in sequence (mutations) that may cause disease.



Roche Genome Sequencer FLX System

Specializing in a method of DNA sequencing called pyrosequencing, Dugway microbiologists are capable of sequencing entire genomes in a short period of time using a Roche Genome Sequencer FLX System. See **DNA Sequencing** for additional information.

The Applied Biosystems® 3130*xl* Genetic Analyzer (16-capillary electrophoresis) is used to analyze variable nucleotide tandem repeats (VNTR), which are short nucleotide sequences that are repeated multiple times in a genome and often vary in copy number, creating a restriction fragment length polymorphism (RFPL). VNTR is a major source of RFPL genetic markers used in linkage analysis of genomes and is used for species identification.

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Production of Biological Agents and Simulants

> *Gram-for-gram, biological weapons are the deadliest weapons ever produced. While few countries are suspected of maintaining offensive biological weapons, many possess the capability to rapidly produce and weaponize biological agents if they chose to do so.* – **The Nuclear Threat Initiative (NTI), a non-profit, nonpartisan organization.**

Production Capabilities Overview

A significant Microbiology Branch capability is the production of large or small quantities of biological agents and simulants used for research and in chamber and outdoor field test programs. Branch staff maintains uniform standards and strict quality control for on-site production of agents and simulants while providing a cost savings to test customers compared to procurement of test materials from outside vendors. Transfer, storage, control, and security of biological materials and toxins are in compliance with U.S. Army Regulation 50-1, Biological Surety.

Microbiologists utilize BSL-2 and BSL-3 laboratories to produce bacteria, fungi, viruses, toxins, agent-like organisms (ALO), biological simulants, and biological aerosols for developmental and operational testing of detection systems, air filtration systems, and fabric swatches. A fermentation facility produces simulate and ALOs; a post-production laboratory dries and mills test material for bioaerosol test and evaluation (T&E) programs; a virology and tissue culture laboratory is used to produce select agents and ALOs.

Bacterial antigens are produced and stored in support of the Critical Reagents Program. The branch serves as the steward of the Critical Reagents Program (CRP) antigen repository which supports warfighters, federal agencies, and the Joint Program Executive Office for Chemical and Biological Defense (JPEO-CBD).

> Life Science Test Facility, Dugway, Utah
> Critical Reagents Program Antigen Repository
> Accredited Reference Material Producer
> ISO Guide 17025 and 34:2009

Biological materials that meet rigorous qualitative and quantitative standards are stored on-site under controlled conditions in freezers or refrigerators.

Biological Agent and Simulant Production

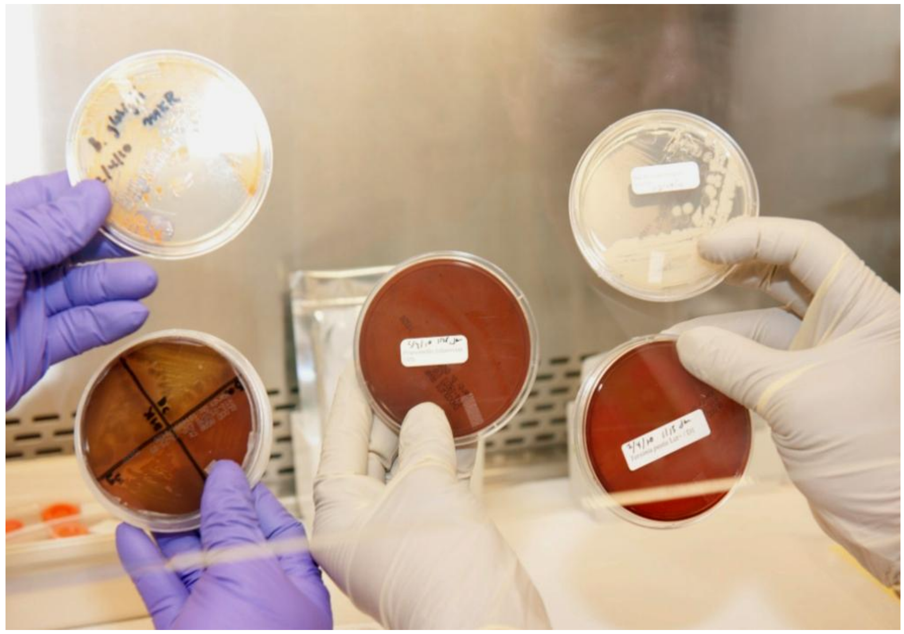
Microbiologists and technicians at the Life Sciences Test Facility (LSTF) have the unique capability to produce and certify biological test materials such as wet and dry agents and simulants, and live and inactivated organisms. The LSTF houses a vast array of facilities, instruments, laboratory equipment, seed stock, tissue cultures, and other biological sources to grow and cultivate biological select agents and toxins, simulants, and organisms that are not contaminated but threat representative.

Each production lot must satisfy conformance tests used for quality control and quality analysis along with a corresponding set of bioanalytical metrics prior to certification as standardized biological material for developmental and operational testing of defense systems.

Biological Select Agents and Toxins

Biological select agents and toxins (BSAT) are microorganisms selected by the Center of Disease Control and Prevention (CDC) and the USDA Animal and Plant Health Inspection Service (APHIS) because they present a high bioterrorism risk to national security and have the greatest potential for

adverse public health impact with mass casualties of humans or animals, or they pose a severe threat to plant health or plant products. The CDC maintains the National Select Agent Registry and attenuated strains of select agents and inactive forms of select toxins are excluded from requirements of the Select Agent Regulations.



BSAT materials are produced in BSL-3 facilities as challenge material for biodefense testing under strict operating procedures and stored in secured refrigerators, freezers, or incubators within the Bioholdings Laboratory. The following are examples of BSAT materials produced and stored for research and testing at Dugway:

- **Bacteria** – Various strains of Bacillus anthracis, Brucella melitensis, Brucella abortus, Brucella suis, Burkholderia pseudomallei, Burkholderia mallei, Francisella tularensis, and Yersinia pestis.
- **Rickettsia** – *Coxiella burnetii* (9 Mile, 9-Mile Phase 1), *Rickettsia prowazekii* (Madrid E)
- **Toxins** – Botulinum neurotoxin (Types A, B, and E), Staphylococcal enterotoxin (enterotoxin B), ricin, abrin.
- **Virus** – Venezuelan Equine Encephalitis (Trinidad), Western Equine Encephalitis (CBA87), Eastern Equine Encephalitis (PE-6)

Agent-like Organisms

Agent-like organisms (ALO) have physiological, physical, and chemical properties similar to those of a corresponding biological warfare agent (BWA) while presenting a reduced risk of infection. ALOs are derived from a vaccine or attenuated strain of BWA, or from a nonviable or inactive form of a BWA.

ALOs are grown from seed stock or produced in fermentors, incubated, and either chemically inactivated or subjected to gamma irradiation to create vaccine-grade microorganisms. Microorganisms killed by the irradiation process are no longer living and cannot produce disease or infections. All BSAT sample preparations for irradiation are conducted in BSL-3 laboratories and by personnel certified in the Biological Personal Reliability Program (BPRP).

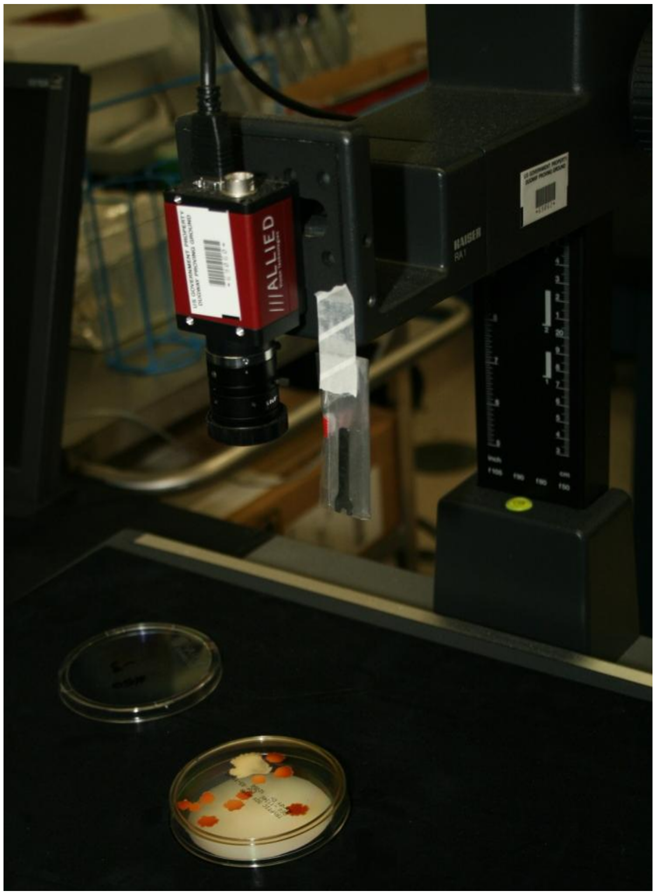
Gamma Irradiation of Microorganisms

Samples of spore-forming bacteria and viruses, such as *Bacillus anthracis*, Venezuelan equine encephalitis (VEE), and *Yersinia pestis*, are loaded into a gamma irradiator and receive a target dose of 40 ±2 kiloGray (kGy) for spore-forming bacteria and viruses, and 10 ±1 kGy for Gram-negative bacteria.

Inactivation of irradiated bacteria is verified by culturing the test material in an enrichment broth for 24 hours subsequent to sub-culturing onto solid agar plates for 48 hours. This method allows cells that are damaged or injured, but not killed to have sufficient nutrients and time to recuperate and begin

replicating. The inactivation of irradiated viruses is verified by transferring the test material to an enrichment culture and then sub-culturing it onto titer plates where any viability is detected by the appearance of plaque-forming units.

If no growth is detected after 96 hours, the test material is declared inactive (nonviable) and a Death Certificate is prepared. The Death Certificate includes the name of the organism, lot number, place and date of inactivation, procedure and dosage used for inactivation, procedure used to confirm the organism is non-viable, and place and date of confirmation.



Other examples of irradiated microorganisms used in test programs include: *Bacillus anthracis* Sterne (BaS), *Bacillus thuringiensis* (Bt), *Yersinia pestis* KIM (YpK), Venezuelan Equine Encephalitis (VEE) TC-83 virus, *Francisella tularensis* live vaccine strain (FtL), and killed *Brucella*.

Chemical Inactivation

Biological warfare toxins may have their toxic properties inactivated through chemical treatments while other properties, such as immunogenicity, are maintained creating a toxoid which may be used in vaccine production. Examples include the abrin toxoid, ricin toxoid, and killed vaccinia.

The botulinum toxin is a protein produced by the bacterium *Clostridium botulinum* and is a powerful neurotoxin (Types A-G) that causes serious and life-threatening illnesses in humans and animals. A formaldehyde inactivation solution chemically alters the toxic properties of botulinum toxin to render it non-neurotoxic by reduction (≥1000-fold) or total removal of the toxic properties. Dialysis removes the residual formaldehyde from the toxoid. The botulinum toxoid is further tested to verify the reduced activity.

An Inactivation Certificate is prepared for biological toxins certifying the biological toxin is free of living organisms, including spores. The Inactivation Certification includes the toxoid name, lot number, place/date of inactivation, procedure used for inactivation, and study used to verify inactivation.

Death and inactivation certificates are included with packages containing inactivated organisms that are shipped from Dugway.

Biological Simulants

The Microbiology Branch produces a variety of biological simulants in small and large quantities to meet developmental and operational test requirements. Simulants are non-pathogenic microorganisms or biological substitutes used as model organisms in place of more lethal biological agents. Simulants attempt to approximate human pathogens in nucleic acid composition, genomic size, and virus particle size.

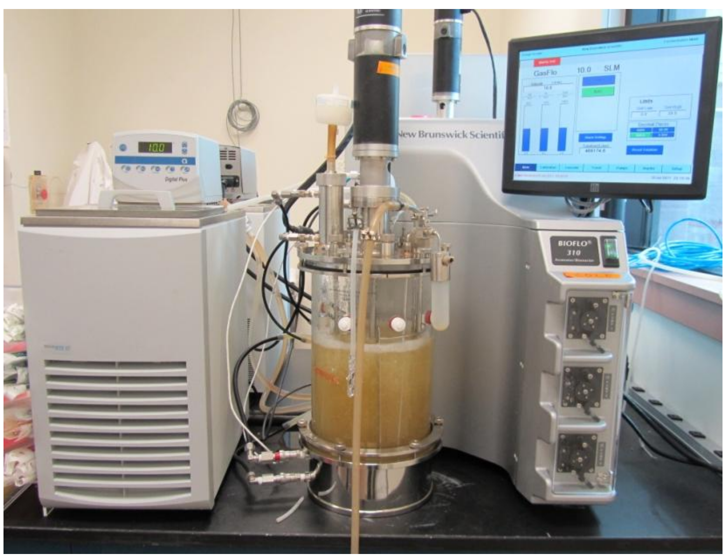
The most commonly-used simulant used in Dugway test programs is *Bacillus atrophaeus* (BG), formerly known as *Bacillus subtilis* var. niger and *Bacillus globigii*. BG is a gram-positive, aerobic, straight rod that grows in chains and is used in place of *Bacillus anthracis* for field testing or as a substitute for pathogentic bacteria. *Bacillus thuringiensis* var. kurstaki (BtK) and *Bacillus thuringiensis* var. aizawai, found in commercial dry biological insecticides, are produced as an alternative for BG spores.

Male-specific bacteriophage type 2 (MS2) is grown and purified for use as a pathogenic virus simulant in place of small RNA viruses, such as the equine encephalitis alphaviruses, Ebola virus, and the Marburg virus. *Erwinia herbicola* is a rod-shaped, non-pathogentic, gram-negative facultative anaerobe used in place of other gram-negative pathogens, such as *Yersinia pestis* and *Francisella tularensis*. Ovalbumin, which is derived from chicken eggs, is used in place of protein toxins such as ricin and botulinum toxin.

Quality Control and Analysis

Upon the completion of a batch lot, samples are validated to ensure the batch conforms to a set of predefined quality metrics, including: genome equivalents (GE) by real-time PCR; assays to determine total protein concentrations; ECL immunoassay for antigen detection and enumeration; microbial identification using a Sherlock® Microbial Identification System (MIDI, Inc.); and variable nucleotide tandem repeats (VNTR) analysis.

Conformance test acceptance criteria includes: correct morphology and purity; colony-forming units of GE (<10 lot-to-lot specific); plaque-forming units of GE (<10 lot-to-lot specific); number of colony-form units (<10 lot-to-lot specific); VNTRs having the correct genotype-lot specific; Pierce bichronic acid (BCA) protein assay (<10 lot-to-lot specific); and microbial identification >70% match (lot-to-lot specific).



New Brunswick Scientific Bioflo® 310 Fermentor/Bioreactor

Production Equipment

The Life Sciences Division features the equipment and instrumentation to produce microorganisms for biodefense test programs and for use within the Critical Reagents Program. Equipment includes fermentation systems, centrifuges, incubators, lyophilizers, bulk milling machines, and particle characterization instrumentation.

Fermentors

The fermentation laboratories at the LSTF grow bacteria, yeasts, and fungal cells in fermentors ranging from small 2 L benchtop units to a bulk 1500 L system. The growth medium for fermentors is tailored specifically to the requirements of the microorganism that is being engineered as the pH, temperature, light, pressure, and nutrient concentrations that give the microorganism optimal growth rates (90% sporulation) are selected and prepared.

The BioFlo®310 (New Brunswick Scientific) benchtop fermentor and bioreactor systems are used to grow small batches (2-40 L) of microorganisms and can regulate up to 32 parameters each in up to four

vessels simultaneously. A 15-inch touchscreen display allows integration of up to 10 sensors, scales, analyzers, and other external devices.

A microbiologist inspects a 1500 L fermentor during a simulant production run

The BioFlo® 4500 (New Brunswick Scientific) is an industrial fermentor (40 to 300 L) driven by NBS ML-6100™ multi-loop controller for on-screen entry of process control loops, sterilization cycles, and calibration routines. Used to produce agent-like organisms and simulant materials for biological defense testing, the BioFlo® 4500 is capable of rapid temperature shifts in growth phase to allow for heat induction.

The BioStat D1500 (B. Braun Biotech International) is the largest-capacity (1500 L) fermentation system and features automatic pH control, oxygen supply, and solvent feeding system. This fermentor allows the production of bulk quantities of bioaerosol material used in detector test programs.

Centrifuges

Beckman Coulter centrifuges are used to concentrate, characterize, or clarify microorganisms and cells by separating components of fluids or mixed suspensions, and removing the particulate matter. The centrifuges can utilize a variety of rotors with six-liter batch throughput for bacterial and cell membrane isolation at forces up to 15,900 x g.

The Beckman Avanti J-20 centrifuge provides rapid pelleting of bacteria and other solids. Following fermentation, the centrifuge processes up to 6 liters to separate solids, such as bacteria, yeast, or protein precipitates from associated culture broth or other liquids. Centrifuges are used to separate pure antigen used in test programs.

A microbiologist inspects the bulk milling system

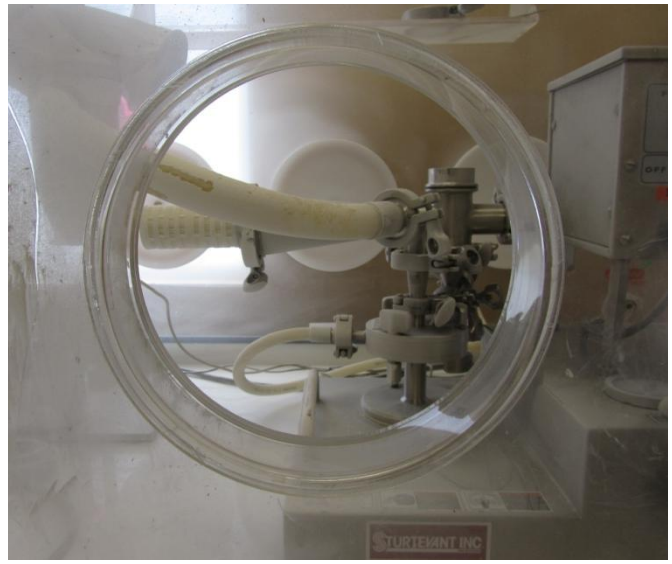
Drying and Milling

Lyophilizers are used to freeze-dry and prepare biological simulant agents used in testing. The VirTis/SP Industries Advantage +SL bench-top freeze dryers achieve shelf temperatures as low as -57°C and condenser temperatures to -67°C.

The bulk milling facility produces large quantities of bioaerosol simulant, such as BG, BtK, *Bacillus thuringiensis* var. israelensis (BtI), and branch absorbing structures (BAS) spores used in large-scale field and chamber testing at Dugway. Two renovated mustard boxes provide a clean, controlled environment to mill bulk organisms from wet microbial fermentation to a final dry-powder product.

The new milling laboratory was designed to isolate actual milling operations from the rest of the milling laboratory area. The milling laboratory has small and large capacity milling equipment that are enclosed within either a glove box or inside a Plexiglas® sealed enclosure. During milling operations, a room dividing curtain separates milling activities from the rest of the milling laboratory area.

The Sturtevant Sanitary Design Micronizer® (SDM) is a jet mill that uses a fluid energy grinding system to generate particle-on-particle impact. The SDM grinds and classifies powders to micron and sub-micron sizes using compressed air or gas.



Sturtevant jet mill

Biological Particle Characterization

The Morphologi G3 (Malvern Instruments Ltd.) is an integrated, dry powder dispersion system that allows all instrument variables (focus, light intensity, magnification, etc.) to be objectively recorded and controlled. The instrument is used to microscopically characterize dried biological powders for analysis, especially pathogenic bacteria. In addition, the Morphologi G3 characterizes aerosol chamber and field test samples. Fermentation QA/QC utilizes the high-resolution imaging system of every particle in a sample (n=5,000 to 500,000) while the software computes statistically significant particle shape, count, and size information.

Autoclaves

Autoclaves are used to sterilize equipment, apparatus, and biological waste materials, before washing, storage, or disposal. Equipment and materials are heated to 121°C under a pressure of 103 kPa for at least 30 minutes (or 1 hour for BSL-3 material).

Quality checks are conducted using indicator strips, data loggers, or spore suspensions to verify that the autoclave functioned properly; if a spore suspension, strip, or indicator tape indicates that the sterilization operation failed to kill test bacteria, the autoclave will be reloaded and run again. After sterilization, waste material can be disposed by conventional disposal systems based on Dugway procedures.

Stainless steel modular wall sterilization system at Baker Lab

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Storage Systems

Storage freezers

LSD has two storage categories for BSAT: long-term storage that includes BSAT not in active use that are stored in the bioholdings facility, located in Building 2029; and working stock which includes BSAT in active use or to be used in the near term (within 6 months). Secure refrigerators and ultra low temperature (to -135°C) freezers maintain tissue culture cells, vaccinia, bacteria, and other microorganisms until ready for use. Stock materials to be used for near-term testing are typically stored at 4°C; materials stored for long-term testing are typically stored at approximately -70°C.

Personnel audit working stocks and monitor programs to ensure the materials are stored within allowable limits. Two authorized individuals must be present with access keys to enter the bioholdings facility. Bioholdings has an intrusion detection system and numerous administrative controls in place for the storage and removal of BSAT.

Attenuated strains of a select biological agent or toxin that does not pose a severe threat to public health and safety, animal health, or animal products are excluded from the list of select biological agents and toxins.

Critical Reagents Program

The Critical Reagents Program (CRP) supports the warfighter, federal agencies and the Joint Program Executive Office for Chemical Biological Defense (JPEO-CBD) as the principle resource of high quality, validated, and standardized biological detection assays and reagents. The program supports the biological defense community by facilitating the transition of new technologies and coordinating their advanced development, efficient production, and timely distribution.

CPR products include antibodies, inactivated antigens, genomic materials, electrochemiluminescence (ECL) assays, PCR assays, lateral flow immunoassays (LFI), and biological sampling kits. As the site of the CRP antigen repository, Life Sciences Division staff produces bacterial antigens, acquires viral and toxin antigens from commercial sources, performs conformance tests on antigens, stores, and distributes to permitted customers. The Life Sciences CRP antigen repository is accredited as a reference material producer by The American Association for Laboratory Accreditation (Certificate Number 3013.01).

Antigens produced and maintained at Dugway are used by the biological defense community for purposes such as antibody production or to serve as challenge material and positive controls in the development and testing of new detection and diagnostic technologies. In addition, branch scientists have supported CPR initiatives, including:

- Collaborating with other CRP facilities to study toxin/toxoid homogeneity and stability and to facilitate validation of PCR reagents
- Comparing lateral flow immunoassay responses from live and inactivated select agent antigens
- Development of a production method for anaerobic bacteria of Clostridium
- Creating a database of infrared spectra collected from CRP antigens

Biological Surety and Safety

It is the policy of the United States that: A robust and productive scientific enterprise that utilizes biological select agents and toxins (BSAT) is essential to national security; BSAT shall be secured in a manner appropriate to their risk of misuse, theft, loss, and accidental release; and security measures shall be taken in a coordinated manner that balances their efficacy with the need to minimize the adverse impact on the legitimate use of BSAT. – **President Barak Obama, Executive Order 13546 – Optimizing the Security of Biological Select Agents and Toxins in the United States, July 2, 2010.**

Biosurety Overview

U.S. Army policy states that biological select agents and toxins (BSAT) in the possession or custody of the Army shall be properly safeguarded against theft, loss, diversion, or unauthorized access or use, and that operations with such agents are conducted in a safe, secure, and reliable manner (U.S. Army Regulation 50-1, Biological Surety).

Select agents and toxins have been declared by the U.S. Department of Health and Human Services and by the U.S. Department of Agriculture as having the potential to pose a severe threat to public health and safety. Select agents and toxins include: *Bacillus anthracis*, botulinum neurotoxins, *Coxiella burnetii*, ricin, monkeypox virus, *Yersinia pestis*, and Venezuelan equine encephalitis (VEE) virus. The National Select Agency Registry, maintained by the Centers for Disease Control and Prevention (CDC) and the Animal and Plant Health Inspection Service (APHIS), lists all current select agents and toxins. An attenuated strain of a select agent or an inactive form of a select toxin is excluded from the National Select Agent Registry.

The Life Sciences Division (LSD) has developed and implemented Biological Surety (biosurety) and Biological Safety (biosafety) programs that are compliant with AR 50-1 and Army Pamphlet 385-69, Safety Standards for Microbiological and Biomedical Laboratories. PAM 385-69 outlines technical safety requirements for the use, handling, transportation, transfer, storage, and disposal of infectious agents and toxins rated at biosafety level 2 (BSL-2) and above.

The four primary segments of the LSD biosurety program are:

- Personnel reliability
- Physical security
- Agent accountability
- Biosafety

Biosurety and Biosafety

The biosurety and biosafety programs at Dugway Proving Ground (DPG) are designed to protect the local workforce, public, and the environment against unauthorized access or unsafe use of BSAT. Enhanced security systems and stringent operating procedures are established to safeguard the select agents from potential external threats while the personnel reliability program is designed to prevent compromise from insider actions.

As a Biological Defense Research, Development, Test, and Evaluation (RDT&E) facility, LSD has developed biosafety programs that comply with: Center for Disease Control (CDC) Code of Federal Regulations 42 CFR 73, 7 CFR 331, and 9 CFR 121; the Department of Defense (DoD) and Army regulations; Occupational Safety and Health Administration (OSHA) requirements for health and safety; Environmental Protection Agency (EPA) regulations that implements the Resource Conservation and Recovery Act (RCRA) and National Environmental Policy Act (NEPA); Nuclear Regulatory Commission (NRC) requirements for safe handling of radioactive isotopes; and relevant federal, state, and local regulations.

Personnel Reliability

The Life Sciences Biological Personnel Reliability Program (BPRP) ensures that each individual who is authorized access to BSAT, and who escort or grant access to BSAT, meet the highest standards of integrity, trust, and personal reliability. Determination of integrity and reliability is accomplished, in part, through initial and continuing evaluation of individuals assigned to duties associated with BSAT. The continuing evaluations ensure these individuals do not pose a risk to public health, safety, or national security.

Individuals identified by the Life Sciences Division Chief as having a legitimate need to access BSAT and storage facilities are screened for suitability and reliability. Candidates must meet qualifying standards that include: an interview to determine competency and technical proficiency, a security investigation adjudicated to national security standards, a medical examination, and a test for illegal drug/substance use before BSAT certification. In addition, all candidates who use or have access to BSAT also undergo a security investigation and specific registration process with CDC and APHIS.

Physical Security

LSD has developed a security plan that detects, assesses, deters, communicates, delays, and responds to unauthorized attempts to access BSAT. An intrusion detection system (IDS) is installed on every BSAT laboratory and in long-term storage which detects and reports an unauthorized penetration into the facility. The perimeter entrance to long-term storage is under constant visual surveillance by closed-circuit television to prevent unauthorized entry.

Access to long-term storage and the BSAT laboratories is allowed only to individuals who have successfully completed the BPRP program, are certified by the certifying official, and have been approved by CDC or APHIS. Individuals requiring access to BSAT who are not BPRP-certified, must be escorted and supervised by at least one person certified in the BPRP. A two-person access system is used during all biological surety operations and tests, when in close proximity to BSAT containers, or where there is an opportunity to acquire, release, tamper with or come in direct contact with biological surety materiel.

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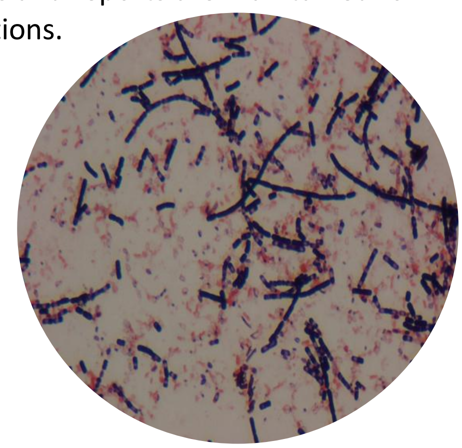
Agent storage areas feature automated biometric access control systems, video monitoring systems, and tracking of individuals who utilize and store agents. All BSAT is stored in secured containers, including refrigerators, freezers and other approved storage devices within long-term storage; BSAT reference stock is secured in a manner that requires two certified individuals to verify and remove BSAT.

Agent Accountability

An inventory control and reporting system is maintained and secured to prevent unauthorized access and to account for all BSAT authorized for certified activities. Inventory control includes names of BPRP-certified personnel approved for access; current inventory of BSAT including type and quantities; an automated system of date/time personnel entered and exited long-term storage; documentation of all BSAT accessed and its final disposition (including names of persons accessing BSAT, culture, destruction, and return to reference stock).

Agent accountability requires detailed documentation for each agent selected for use, including agent identity, purpose and quantity, storage locations, and identity of handler. Long-term storage includes BSAT not in active use that is stored in the long-term storage facility. Working stock includes BSAT in active use or to be used in near term (within 6 months).

Records and reports maintained include: security incident reports, and threat and vulnerability assessments; inspection and exercise records and reports; corrective actions/improvements; emergency response plans, and employee training records. Records and reports are maintained for five years and then adjudicated according to administrative instructions.



Procedures are in place for the transfer, storage, use, and shipment of BSAT. These procedures include:

- Requests for long-term storage of BSAT
- Requests for removal of BSAT from long-term storage
- Requests to transfer BSAT to another registered facility
- BSAT transfer from long-term storage within the LSTF
- Transfers of BSAT outside the LSTF but within the WDTC
- Shipments to domestic or internationally approved locations
- Receipt of BSAT from other facilities

Additional agent accounting procedures cover audits of working stocks, inventories, reporting of a theft, loss, or release of a select agent, and general recordkeeping requirements. BSAT may not be shipped, transferred, used, or stored without approval of the biosafety officer and responsible official. Laboratory supervisors and technicians ensure that only those select agents listed on each laboratory's most recent CDC registration are procured, used, stored, or shipped from the lab. The biological storage custodian ensures that all activities involving BSAT are documented and are reflected in the database.

Biosafety

The Biosafety Program ensures that individuals adhere to specific safety policies and procedures, follow good laboratory practices, and utilize designated personal and physical safety equipment.

Biological risk assessments are conducted to determine the biological safety level (BSL) for handling an infectious agent or toxin. Procedures for defining BSLs are contained in the Biosafety in Microbiological and Biomedical Laboratories (BMBL), HHS Publication No. (CDC) 21-1112, and PAM 385-69. BSLs are four ascending levels of containment (BSL-1 through BSL-4) which describe the microbiological practices, safety equipment and facility safeguards for the corresponding level of risk associated with handling a particular infectious agent or toxin. Risk levels are based on infectivity, severity of disease, the availability of preventive measures and effective treatments for the disease, transmissibility, the nature of the work being conducted, and the origin of the agent (whether indigenous or exotic).

Safety controls are identified through a risk management process to include:

- Facility safety controls (e.g., directional airflow, backup power)
- Safety equipment (e.g., biosafety cabinets, glove boxes)
- Proficiency levels of laboratory personnel
- Laboratory practices
- Safety requirements
- Personal protective equipment
- Access control, signage and labeling
- Medical surveillance and immunizations
- Disinfection and sterilization
- Hazardous biological waste handling, decontamination, packaging, and disposal
- Emergency procedures

Institutional Biosafety Committee

The Dugway Institutional Biological Safety Committee (IBC) is responsible for the oversight, administration, and review of West Desert Test Center (WDTC) policies and projects involving work with infectious agents and toxins (IAT) that may pose a risk to public health, safety, or the environment. An IAT is any fungi, virus, bacteria, prion, Rickettsia, viable microorganism or its toxin, or a prion that lacks nucleic acids, that causes or may cause disease, and any material of biological origin that poses a degree of hazard similar to those organisms.

The IBC collaborates with test officers, scientists, principle investigators, branch chiefs, and installation subject matter experts (SME) to ensure that the biological aspects of testing, evaluation, and methodology development are conducted in a safe manner using established biosafety standards, principles, and functions. Safe testing and evaluation/methodology development includes worker safety, public health, agricultural and environmental protection, ethics, and compliance with applicable biosafety standards and LSD policies.

The IBC meets on a quarterly basis and ad hoc committees may be established to review protocols and programs that may occur between quarterly meetings, or to address major changes in previously presented protocols/programs. The Biosafety Committee reviews test procedures whenever 1) the test is new and requires the use of IAT; 2) a major change has been made to test requirements (e.g., the amount of agent used, the test procedure, the agent requirements have changed); and 3) the test includes work with recombinant deoxyribonucleic acid (rDNA).

When required, the biosafety committee reviews test protocols to ensure that BSAT and BSAT quantities used or produced are within allowable limits and are safely and securely stored and handled.

The IBC is responsible for:

- Determining biosafety levels for unclassified organisms
- Reviewing the design for new and modified containment facilities
- Reviewing and implementing LSD policies
- Reviewing work with rDNA molecules and functions as stated in the NIH Guidelines for Research Involving Recombinant DNA Molecules.

Researchers and test officers are required to present new projects or programs for approval that will use BSAT or infectious agents.

Biological Emergency Response Assistance Plan Team

The Biological Emergency Response Assistance Plan (BERAP) Team is a group of LSD employees trained to respond to emergencies within the LSTF. Team members are trained in: cardiopulmonary resuscitation (CPR) and first aid as per the American Heart Association Guidelines for Basic Life Support; Federal Emergency Management Association (FEMA), National Incident Management System (NIMS), Incident Command System 100 (ICS-100) protocol and basic chemical, biological, radiological, and nuclear (CBRN) awareness; and patient decontamination training.

The team consists of an Incident Commander (IC) who is responsible for maintaining communications with the command post and BERAP team, aid specialists who handle casualty assessments and first-aid, and decontamination specialists who are responsible for contamination assessments and decontamination. BERAP team members are cross-trained to function in multiple areas and participate in quarterly Biological Mishap and Incident Response (BMIR) drills and exercises.

TESTING TECHNOLOGY TRAINING

LIFE SCIENCES TEST FACILITY

Life Sciences Division Program Support

The following is a partial list of recent programs and organizations supported by the Life Sciences Division:

Programs

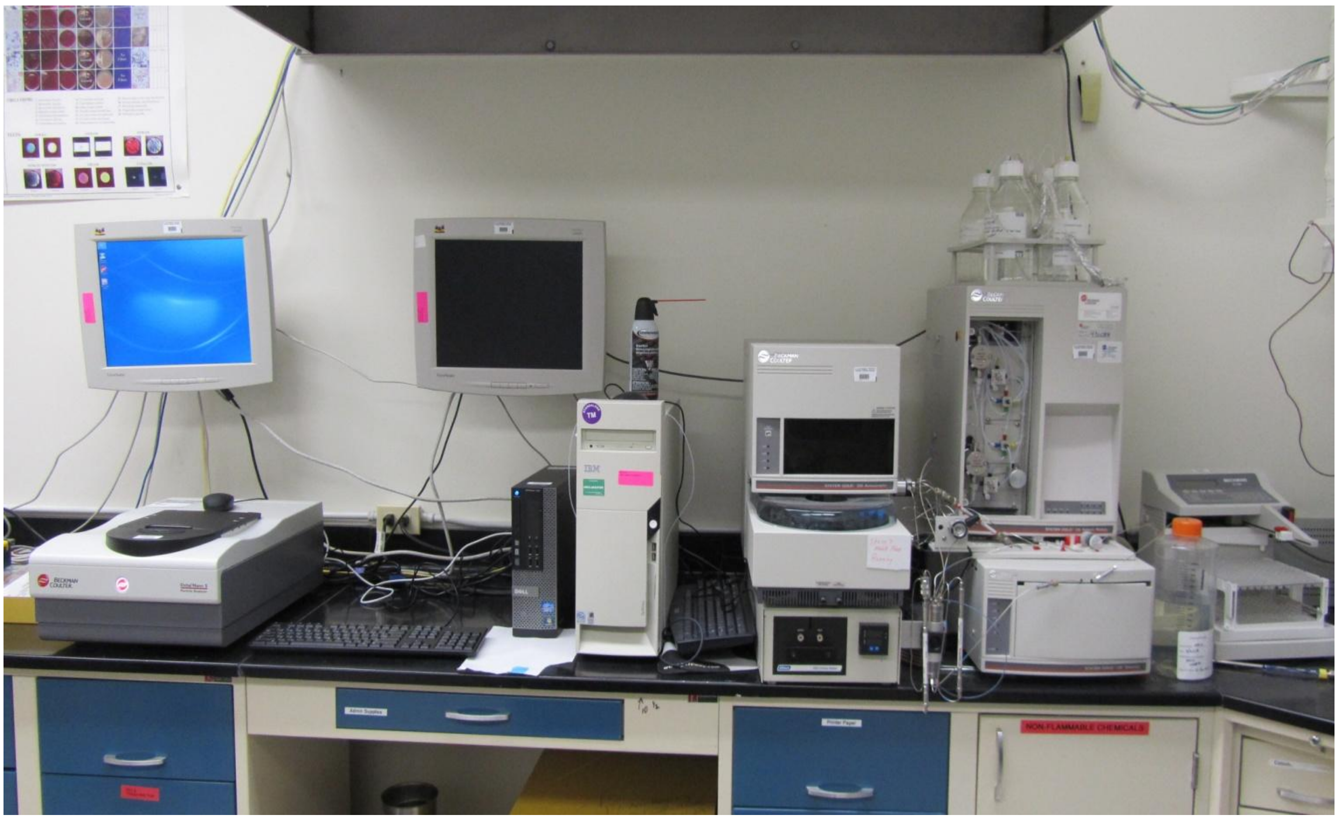
- BioWatch Program
- Chemical-Biological Active Standoff System (CBASS)
- Chemical and Biological Defense Program (CBDP)
- Chemical-Biological Detection System (CBDS)
- Chemical-Biological Protective Shelter (CBPS)
- Civil Support Team Training
- Critical Reagents Program (CRP)
- Joint Biological Agent Identification and Diagnostic System (JBAIDS)
- Joint Biological Point Detection System (JBPDS)
- Joint Biological Tactical Detection System (JBTDS)
- Joint Chemical Biological Radiological Agent Water Monitor (JCBRAWM)
- Joint Warning & Reporting Network (JWARN)
- Medical Countermeasures Initiative
- Rapid Agent Aerosol Detector (RAAD)
- Stryker Nuclear, Biological, and Chemical Reconnaissance Vehicle (NBCRV)
- Whole System Life Agent Test (WSLAT)

Organizations

- Center for Disease Control and Prevention (CDC)
- Defense Threat Reduction Agency (DTRA)
- Environmental Protection Agency (EPA)
- Joint Program Executive Office for Chemical and Biological Defense (JPEO-CBD)
  - JPM-Biological Defense
  - JPM-Nuclear, Biological, and Chemical Contamination Avoidance
  - JPM-Guardian
  - JPM-Protection
  - JPM-Chemical Biological Medical Systems
  - JPM-Medical Countermeasures ADM
- National Ground Intelligence Center (NGIC)
- Rapid Integration and Acceptance Center (RIAC) Unmanned Aircraft Systems (UAS)
- Research, Development and Engineering Command (RDECOM)
- Special Programs Division
- U.S. Department of Agriculture
- U.S. Department of Defense
  - The National Guard
  - U.S. Army
  - U.S. Navy
- U.S. Department of Health and Human Services
- U.S. Department of Homeland Security
- U.S. Department of Justice

Section 4.1

Life Sciences



Technologies

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Aerosol Simulant Exposure Chambers (ASEC)

Division: *Life Sciences* **Branch:** *Aerosol Technology*

Capability Summary

The Life Sciences Division's two Aerosol Simulant Exposure Chambers (ASEC1/ASEC2) are large (75 m^3) biosafety level 2 facilities used to test biological point detectors and to perform contamination/decontamination survivability tests. ASEC1 is housed in the Life Sciences Test Facility (LSTF) and ASEC2 is located in Building 2033 within the Life Sciences complex.

The chambers allow for aerosolization of live biological simulants, inactivated agent-like organisms (ALO), and killed biological simulant. ASEC challenge material has included: *Bacillus atrophaeus* (BG), *Erwinia herbicola* (EH), *Bacillus anthracis* Sterne (vaccine strain), *Yersinia pestis* (Kim), Venezuelan Equine Encephalitis TC-83 (vaccine strain), *Clostridium botulinum* toxoid, and Vaccinia virus Lister (Elstree).

Capability Description

The stainless steel-lined chambers are 5x5x3-meters and feature environmental and airflow control systems. Chamber temperature can be adjusted from 4° to 40°C; a steam system and dehumidifier can provide relative humidity (RH) from 5% to 100%. The chambers are set to maintain negative pressure of 0.5 iwg during tests.

Life Sciences technicians typically disseminate bioaerosol clouds with Sono-Tek ultrasonic atomizing spray nozzles which provide near-monodisperse particle generation of approximately 1 to 6 µm in size. The particles contain approximately eight spores each and can be distinguished from smaller background particles. Other dissemination methods used within the ASECs have included Micronair spray systems (polydispersed particles), commercial off-the-shelf (COTS) pesticide sprayers, and an ink jet aerosol generator (IJAG) system. Dugway also has various custom-built powder disseminators which are available for use within the ASEC.

Aerosol Simulant Exposure Chamber control room

The chambers include two banks of mixing fans (four each) to evenly distribute aerosol particles during dissemination with airflow rates that may be adjusted to 500 cfm. High-efficiency particulate air (HEPA) filters clean intake and exhaust air.

BioWatch Generation 3 test inside Aerosol Simulant Exposure Chamber

A truth box (120x120x48 inches) located inside each ASEC houses the system under test (SUT) and analytical instrumentation, including aerodynamic particle sizers (APS) to monitor particle concentration, all-glass impingers (AGI) to collect biological samples, temperature and humidity probes, and other instruments as required by the test plan. The chambers also have water-resistant GPI duplex outlets, a vacuum system, and a winch capable of lifting 100 lbs.

Prior to the start of a test, operators decontaminate an ASEC by either washing with a 5% bleach solution or using the vaporized hydrogen peroxide (VHP) system. Air washing is typically conducted between trials to minimize contamination levels and includes air exchanges and HEPA filtering to bring natural ambient levels to baseline levels.

Both chambers have been fully airflow-mapped and standard practice includes executing mapping (using mockups) when large equipment is to be evaluated.

Quick Facts

ASEC has supported development of numerous detector systems including:

- Chemical Biological Detector System (CBDS)
- BioWatch Gen-3 detectors
- Joint Biological Point Detection System (JBPDS)
- Joint Biological Tactical Detection System (JBTDS)

Ambient Breeze Tunnel (ABT)

Division: *Life Sciences* **Branch:** *Aerosol Technology*

Capability Summary

Over the past decade, the Ambient Breeze Tunnel (ABT) has provided West Desert Test Center (WDTC) scientists and test officers an environment to control a variety of parameters to test and evaluate full-scale chemical-biological detection systems. Today, the ABT is primarily used to test biological point and standoff detectors and referee equipment, while serving as the bridge between laboratory/chamber and field testing.

Permitted for biosafety level 1 (BSL-1) testing, the ABT allows test officers to control the dissemination of homogenous biological simulants and battlefield interferents under ambient temperature and humidity conditions. The enclosed facility is designed to control cloud concentrations over time while minimizing the effects of external weather conditions.

Capability Description

The ABT is 46x6x6 meters with an arching roof and is open on both ends. The ABT includes a separate aerosol control room, test control room, an administrative trailer, and a heavy-duty ventilation system which can produce airflow up to 150,000 cfm. A furnished command post is located at the site with full data and communications links and may be used by customers and vendors during tests.

Bioaerosols can be generated by a variety of methods, including Micronair sprayers (wet), Skil® blowers (dry), or other systems, using Sono-Tek ultrasonic spray nozzles, which provides scientists the flexibility to produce and control a large range of aerosol concentrations and particle sizes during tests. ALO challenge concentrations are premixed at the Life Sciences Test Facility (LSTF), injected with a syringe infusion pump, and disseminated through mixing baffles.

Quick Facts

The ABT has supported detector development, including:

- Chemical Biological Detection System (CBDS)
- Joint Biological Point Detection System (JBPDS)
- Joint Biological Tactical Detection System (JBTDS)
- Stryker Nuclear, Biological, and Chemical Reconnaissance Vehicle (NBCRV)
- Chemical, Biological, Radiological, and Nuclear (CBRN) Unmanned Ground Reconnaissance (CUGR) Joint Contaminated Surface Detector (JCSD)

Joint Biological Point Detection System (JPBDS) and referee instrumentation test setup inside the Ambient Breeze Tunnel

Target concentrations may range from 0 to 300 agent-containing particles per liter of air (ACPLA) with a target particle sizes ranging from 2.0 to 6.0 µm (target 2.5 µm).

Agent-Like Organisms (ALO) and biological simulants released within the ABT have included: *Bacillus atrophaeus* (BG), *Bacillus anthracis* (Ba) (Sterne), *Bacillus thuringiensis* (Bt), *Yersinia pestis* KIM (YpK), *Erwinia herbicola* (EH), ovalbumin (OV), and MS2 bacteriophage. Interferent releases have included smoke, road dust, burning vegetation, burning tires, and diesel exhaust.

A bank of adjustable fans mix and pull the aerosol clouds through the tunnel with blowers capable of generating wind speeds up to 5 mph at the test area. Aerosol cloud concentrations are typically maintained for approximately 5 minutes.

A detector system-under-test (SUT), referee equipment, samplers, and related instrumentation are set up in the test/sampling section of the tunnel. Sampling towers are erected upwind from the SUT and may include: slit-to-agar (STA) samplers, all-glass impingers (AGI), aerodynamic particle sizers (APS), and high-volume samplers, in addition to temperature and humidity probes. Referee systems may include a Joint Biological Point Detection System (JBPDS) or M31E2 Biological Integrated Detection System (BIDS).

Airflow is drawn through high-efficiency filter panels before exhausting into the environment.

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Containment Aerosol Chamber (CAC)

Division: *Life Sciences* **Branch:** *Aerosol Technology*

Capability Summary

The Containment Aerosol Chamber (CAC), located within the Life Sciences Test Facility (LSTF), is a 7.3 m^3 stainless-steel fixture designed to contain up to biosafety level 3 (BSL-3) aerosols. The CAC is used to challenge detection systems with aerosolized live biological agents, live and killed agent-like organisms (ALO), and biological simulants.

The CAC features glass windows, glove ports, and half-suits for accessibility. An aerosol Mixing Tube Assembly (MTA) enables the controlled delivery of aerosolized agents and simulants into the Detector Challenge Chamber (DCC). The environmentally-controlled DCC is a 1 m^3 glove box constructed of half-inch Plexiglas® in which detector systems under test (SUT) are challenged with bioaerosols.

Concentration ranges for a trial can range from 0 to <12,000 agent-containing particles per liter of air (ACPLA), and a particle size distribution number median aerodynamic diameter of 0.5 µm to 6 µm. Simulants and agents of biological origin (ABO) may include: *Bacillus atrophaeus* (BG), live and gamma (γ)-inactivated *Bacillus anthracis* (Ba), live and γ-inactivated *Yersinia pestis* (Yp), active and inactive botulinum neurotoxin, active and inactive Venezuelan Equine Encephalitis Virus (VEE), live and γ-inactivated Ba (Sterne), live and γ-inactivated Yp (Kim), and active and inactive VEE (TC-83, vaccine strain).

System Description

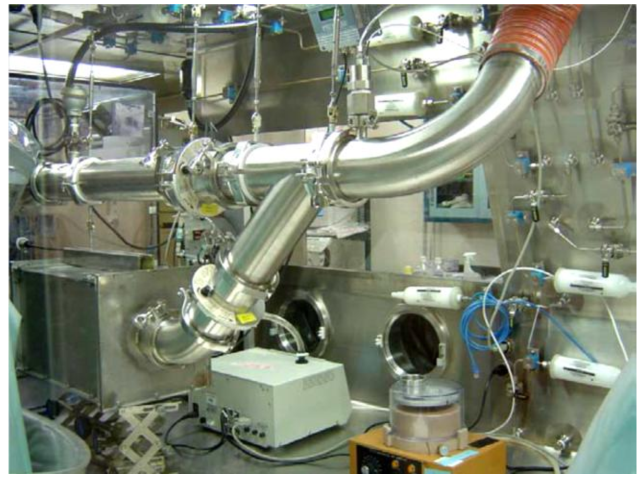
The CAC allows for developmental and operational testing of detection equipment with aerosolized BSL-3 agents, including bacteria, viruses, and biological toxins. Customers can obtain data on a detector's performance prior to field testing, including lower limits of detection, identification, and signal intensity. The chamber also provides a controlled environment to compare and model detector performance by exposure to simulant, live and inactivated ALOs.

Quick Facts

CAC-supported test projects:

- Joint Biological Point Detection System (JBPDS)
- Joint Biological Tactical Detection System (JBTDS)
- Rapid Aerosol Agent Detector (RAAD) of JBPDS
- Whole System Live Agent Test (WSLAT)

The CAC consists of two main components, the MTA and the DCC.



CAC mixing tube assembly

Mixing Tube Assembly (MTA)

The MTA, which is constructed of 4-inch stainless steel pipe, is connected with an elbow to a vertical HEPA-filtered air inlet on the ceiling of the CAC. About one foot downstream from the elbow, the horizontal pipe bifurcates on a vertical plane into the “upper pipe” and “lower pipe.” An iris damper is integrated into each pipe at about one foot downstream from the branching point. In addition, a HEPA filter is installed in line with the lower pipe, downstream from the iris damper.

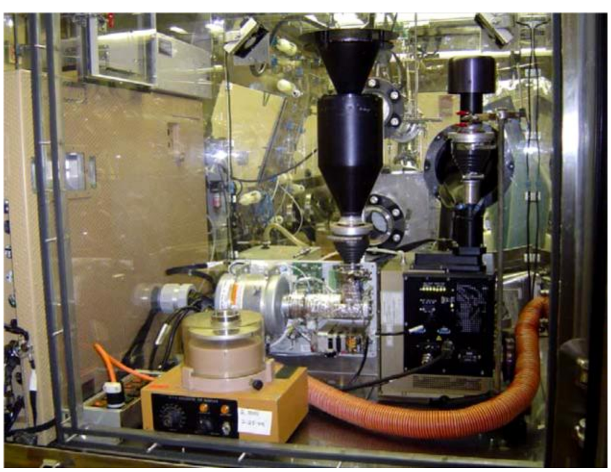
The point of aerosol generation, or dissemination, is located on the horizontal segment of the connecting elbow. The flow of aerosol that enters the upper or lower pipe can be varied by adjusting the size of the openings of the iris dampers, provided the total aerosol flow equals the set point of the inflow air so that no back-pressure is generated.

Particle-laden flow enters the DCC from the upper pipe while particles in the flow that enters the lower pipe are removed by the HEPA filter before the air is discharged into the DCC. The aerosol from the upper pipe and the filtered air from the lower pipe are mixed in the DCC by the nature of the turbulence of the 1.5 m^3/min dynamic flow and the four, 1.5 m^3 mixing fans installed inside the DCC.

Removal of particles from the lower pipe flow allows the final concentration of particles to be reduced to a single-digit percentage of the original output, which would otherwise be unachievable because of the limitation of the aerosol generation system.

Detector Challenge Chamber (DCC)

The DCC is a 1 m^3 glove box constructed of half-inch Plexiglas® in which test items are placed and exposed to aerosols. Aerosol sampling ports for Aerodynamic Particle Sizers® (APS™), all-glass impingers (AGI), slit-to-agar (STA) and Andersen cascade impactors (ACI) are incorporated into the DCC. Access ports for power, communications, and other cables or tubing can be improvised as needed. Aerosol in the DCC is exhausted through a four-inch exhaust port, fitted on the wall of the DCC, to three in-series HEPA filters before it is released into the open space.



CAC Detector challenge chamber

Aerosol is generated with a Sono-Tek ultrasonic spray nozzle system. A syringe pump is employed to deliver the particle suspension to the nozzle. Droplets generated by the energized nozzle are carried into the main stream of the MTA by the inflow system. With the employed aerosol generation system, scientists are capable of controlling particle size number median aerodynamic diameter of 0.5 µm to 6 µm.

Biosurveillance - Rapid Identification of Unknown Microorganisms

Division: *Life Sciences* **Branch**: *Regulatory Science and Innovation*

Capability Summary

Scientists within the Life Sciences Division (LSD) can provide rapid response to federal, state, or local agencies to identify and characterize unknown microorganisms that may pose a threat to human or animal health, plant life, or the environment. The Regulatory Science and Innovation (RSI) Branch employs leading-edge biosurveillance technologies to quickly identify a broad range of infectious microorganisms found in a sample without prior knowledge of what organism is present in the sample.

Microbiologists use the Abbott PLEX-ID™ (Abbot Ibis Biosciences) to screen for known and unknown bacteria, viruses, or fungi in a single analysis directly from the sample. The system can analyze up to 250 samples per day and to provide most results within eight hours. The Abbott PLEX-ID™ workflow allows microbiologists to analyze the genomic information from all types of organisms present in a sample, often without the need to culture or perform isolation prior to analysis.

Capability Description

The Abbott PLEX-ID™ system features multi-locus base composition analysis for microbial identification without the need for prior knowledge of what is in the sample. The system provides a single workflow to analyze bacteria, viruses, fungi, and protozoa; mixtures can be analyzed and results generated within hours. The Abbott PLEX-ID™ also has the capability for all types of DNA testing and interpretation of mitochondrial DNA (mtDNA) mixtures.

Abbot PLEX-ID™

The Abbott PLEX-ID™ system combines several molecular technologies, including polymerase chain reaction (PCR) for gene amplification and mass spectrometry analysis to rapidly characterize known and unknown samples. PCR amplifies the sequence regions specific to the organism of interest; after loading a 96-well plate into the Abbott PLEX-ID™ to desalt the contents of each sample well, the system determines the mass of each amplified product (amplicon) present. The system automatically calculates the composition of nucleotide bases (adenine, guanine, cytosine, and thymine) from the mass of each amplicon present and performs a database search against a library of over 750,000 base composition entries to determine and report the organism present.

The Abbott PLEX-ID™ Biothreat Assay utilizes 33 primer pairs multiplexed into 16 wells to detect and distinguish 17 (13 bacterial and 4 viral) microorganisms that could pose serious threats to human health, food, water, and other resources. The system identifies pathogens such as *Bacillus anthracis*, *Clostridium botulinum*, *Escherichia coli*, *Rickettsia*, Ebola Marburg virus, Venezuelan equine encephalitis, and avian influenza viruses, plus other bacterial and viral agents, while differentiating among 100 near-neighbor organisms.

DNA Sequencing

Division: *Life Sciences* **Branch**: *Microbiology*

Capability Summary

Deoxyribonucleic acid (DNA) sequencing is a methodology to determine the order of nucleotide bases within a molecule of an organism's DNA. Nucleotide bases are purines (adenine and guanine) and pyrimidines (cytosine and thymine) which comprise the DNA chain.

Microbiologists at the Life Sciences Test Facility (LSTF) perform DNA sequencing to analyze the entire genetic code of microorganisms, including bacteria, viruses, biological select agents, and biological simulants, which can be completed within a short period of time. This method has been used to characterize biological strains used in West Desert Test Center test programs.

A Life Sciences Division microbiologist performs DNA sequencing on a Roche Genome Sequencer FLX System.

DNA sequencing has also been used to verify whether certain virus strains are infectious or noninfectious, and to design and build new, organism-specific polymerase chain reaction (PCR) assays by comparing small regions of differentiation between microorganisms.

Capability Description

Genome sequencing analyzes the complete DNA sequence of an organism's genome, including plasmids, or DNA molecules that replicate independently of the bacterial chromosome; chromosomal DNA; and DNA contained in mitochondria, or in plant chloroplast.

The genome contains all biological information required to build and maintain a living organism which is encoded in the DNA and divided into genes. Each base – adenine, guanine, cytosine, and thymine – has a different composition of oxygen, carbon, nitrogen, and hydrogen. Within the DNA chain (double helix), bases are attached to a sugar molecule (deoxyribose) and a phosphate molecule to create nucleic acid or nucleotide. Individual nucleotides are linked through the phosphate group and the precise order (sequence) of nucleotides determines the product (proteins or functional RNA) made from that gene.

Genotyping is a process to determine differences in an organism's genetic characteristics by analyzing the DNA sequence using biological assays and comparing the results to another organism's sequence or to a reference sequence. In humans, it reveals the alleles an individual inherits from his or her parents. Similarly, viral and bacterial DNA are analyzed to identify clades, or common ancestry, specific pathways, molecules, and genes that influence the development of a disease and can be used to trace the origin of an outbreak.

DNA image on Roche Genome Sequencer monitor

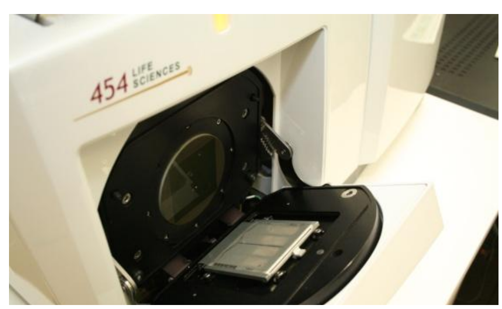
Microbiologists perform genome sequencing using a Roche Genome Sequencer FLX System that allows sequencing on any double-stranded DNA, resequencing whole genomes and target DNA regions, metagenomics, ribonucleic acid (RNA) analysis, and amplicon sequencing. Pyrosequencing is a method scientists use to detect pyrophosphate released during DNA or RNA synthesis whereby enzymatic reactions generate visible light, the intensity of which is proportional to the number of nucleotides being incorporated.

The Roche Genome Sequencer FLX attaches nebulized and adapter-ligated DNA fragments to small DNA-capture beads in a water-in-oil emulsion. The DNA fixed to the beads is amplified by PCR and each DNA-bound bead is placed into an approximate 29 µm well in a PicoTiterPlate™ which uses multiple optical fibers to form an optical array. A mix of enzymes, such as DNA polymerase, ATP sulfurylase, and luciferase are also packed into the well. The PicoTiterPlate™ is inserted into the system to begin the sequencing process.

A fluidics subsystem delivers sequencing reagents (containing buffers and nucleotides) across the wells of the PicoTiterPlate™. Four DNA nucleotides are added sequentially in a fixed order across the plate during a sequencing run. While the nucleotide flows, millions of copies of DNA bound to each of the beads are sequenced in parallel. When a nucleotide complementary to a template strand enters a well, the polymerase extends the existing DNA strand by adding nucleotide(s). The added nucleotide creates a light signal that is recorded by a charge-coupled device (CCD) camera (pyrosequencing).

Additional applications performed by the Roche Genome Sequencer FLX System:

- Amplicon (ultra deep) sequencing allows mutations to be detected at extremely low levels of DNA. PCR amplifies specific regions of DNA to identify low frequency mutations or rare variants in a virus.
- Metagenome sequencing to analyze genetic material recovered from complex environmental samples. This method characterizes a microorganism within an environmental sample and is used to determine the role of the microorganism within the environment.
- Transcriptome sequencing encompasses small RNA profiling, mRNA transcript expression analysis, and analysis of full-length mRNA transcripts. The system may be used to investigate new gene discoveries, gene space identification in new genomes, assembly of full-length genes, single nucleotide polymorphism (SNP), insertion-deletion, and splice-variant discovery.



Pico TiterPlate

Individual Water Purification System Testing

Division: *Life Sciences* **Branch:** *Aerosol Technology*

Capability Summary

The U.S. warfighter continues to be deployed to remote regions of the world where supplying bottled water to maintain daily hydration requirements is a costly and logistical encumbrance. Purification of indigenous waters has become a viable alternative of supplying potable water through removal or inactivation of pathogens, parasites, chemicals, and inorganic contaminants.

The Life Sciences Division (LSD) has the validated facilities and expertise to determine the efficacy of individual water purification systems (IWPS) prior to being issued for production and use in the field of operations. Microbiologists test and evaluate IWPS to determine if the system meets filtration standards as defined in the U.S. Environmental Protection Agency (EPA) Guide Standard and Protocol for Testing Microbiological Water Purifiers.

Capability Description

Current U.S. military fluid replacement guidelines recommend the consumption of approximately 1 to 3 gallons of water per day in warm/hot environments based upon a soldier's level of work activities. Since numerous military operations are performed in desert climates, the challenge is to avoid performance degradation from heat-related incidents by maintaining proper hydration through treatment of local water supplies.

Dugway microbiologists have developed the systems and procedures to evaluate the suitability of military IWPS based on NSF International (formerly National Sanitation Foundation) protocols P231 (Microbiological Water Purifiers) and P248 (Emergency Military Operations Microbiological Water Purifiers). Tests and evaluations have been performed on well-characterized IWPS under the NSF protocols and validated by comparing results of prior NSF studies and the results of IPWS component studies from independent laboratories funded through the Small Business Innovation Research (SBIR) program.

Microbiological contaminants in water may include: Biological Select Agents and Toxins (BSATs) including *Coxiella burnetii*, Ricin, and *Yersinia pestis*; bacteria, such as *Escherichia coli* (*E. coli*); viruses, including influenza strains, rotavirus, and poliomyelitis; protozoa, such as *Giardia*, *Cryptosporidium*, amoebae; and protozoan cysts and oocysts. LSD is authorized to use live *Cryptosporidium* in test programs, while bacteria not known to cause disease in humans, such as *Raoultella terrigena* (*R. terrigena*), male-specific bacteriophage MS2, and fr coliphages, are used to test an IWPS filtration system.

Water purification test effluent processing

Dugway microbiologists challenge a series of IWPS with contaminated water at various concentrations of biological and chemical constituents, while controlling parameters such as: total chlorine, dissolved solids, alkalinity, turbidity, pH, total organic carbon (TOC), and temperature. Controlled titers of bacteria and protozoa are added to test waters, which are sampled and cultured through incubation.

Enumeration by counting colony-forming units (*R. terrigena*) or plaque-forming units (coliphage), or through cyst count (*Cryptosporidium*) under a fluorescent microscope determines the efficacy of an IWPS. Each IWPS must meet performance standards of a minimum 99.9999% (6-log) reduction or inactivation of bacteria, 99.99% (4-log) reduction/inactivation of viruses, and a 99.9% (3-log) reduction/inactivation of protozoan cysts.

Individual water purification test fixture

Aseptic sampling technique demonstration inside an Aerosol Simulant Exposure Chamber

Biological Defense Training

Division: *Life Sciences* **Branch:** *Regulatory Science and Innovation*

Capability Summary

A primary initiative at Dugway Proving Ground (DPG) is to provide training and practical exercises for weapons of mass destruction (WMD) civil support teams (CST). The Life Sciences Division (LSD) training team consists of specialists with expertise in a variety of sophisticated biological analytical equipment and processes, such as and immuno-based detection and identification methods and polymerase chain reaction (PCR) analysis. In addition, biological trainers serve as the biological threat-training experts for the West Desert Test Center (WDTC) by maintaining proficiency in biological forensic sampling and simulant development for bioterrorism training.

Classroom and hands-on training is conducted inside the biosafety laboratories (BSL-1 and BSL-2) at the Life Sciences Test Facility (LSTF) and within Dugway's unique training facilities. See **Specialized Test and Training Facilities and Programs** for additional information on DPG training capabilities, courses, and realistic training environments.

Capability Description

The training team develops and maintains working familiarity with new technologies and are adept at effectively teaching difficult principles to a wide variety of audiences, including U.S. military personnel, CSTs, and first responders in detecting and identifying potential biological hazards and proper sampling of biological threat agents. Courses emphasize hands-on training and all course materials and field training exercises are designed to enhance a unit's capabilities and to meet training objectives. When training activities are not being conducted, LSD team members work within BSL-3 laboratories, produce biological agents and simulants, or conduct test programs.

Quick Facts

Dugway Proving Ground has hosted numerous WMD civil support team lab courses, field training exercises, and mobile training teams since 1999 and played an integral role in the validation of the first 11 WMD CSTs at Fort Leonard Wood, Missouri.

Microscope training is conducted in CBC Level 1 and 2 courses, as well as the microscopy course

Dugway microbiologists and chemists who work with agents and simulants in the laboratories collaborate to present CST courses in small groups. Dugway provides the unique opportunity to work with attenuated strains of *Bacillus anthracis*, *Yersinia pestis*, and *Francisella turlarensis*. Realistic scenarios train customers to safely and aseptically collect samples and perform presumptive field exercises. Recognizing the signatures of biological and chemical production facilities prepares CST members to make correct decisions when called to investigate a white powder or any other WMD incident.

CST Level I biological course modules include: the reconnaissance and sampling of a clandestine lab; collecting a viable laboratory sample and running preliminary tests for presumptive analysis; practicing aseptic sampling methods; learning how powders behave after dissemination and collecting samples outdoors; biological hazardous materials assessments; creation of microscope slides of bacteria and comparing morphology with various white powders; and operating a RAZOR™ (Idaho Technology, Inc.) biodetection system and R.A.P.I.D.® System (Idaho Technology, Inc.) for PCR analysis.

CST Level I chemical course includes: chemical agent signatures and production; chemical synthesis, including half-mustard blister agent; toxic industrial chemicals (TIC); nicotine extraction with hydrogen cyanide and cyanosin chloride synthesis; recognition of various glassware and sample points; dissemination and dispersal of chemical weapons; contamination and decontamination of PPE, including reactivity of various chemical agents with the decontamination solution; extracting solanine from the night shade family using various reflux and distillation methods; and detector systems, including challenging chemical detectors with agents and simulants.

CST Level II courses focuses on in-depth sample analysis and the specific aspects of chemical and biological dissemination, sample collection, and presumptive testing. Customers use sample collection equipment to collect a disseminated powder, run presumptive hand-held assays, and PCR analysis. Chemical modules include: instruction on home-made explosives and peroxide and fertilizer explosives; chemical agent production and precursors; and blood agents and poisons.

Training with vaccine strains in a BSL-2 lab

Additional biological courses include:

- **Virus Course** – This course focuses on egg inoculation with a virus and viral harvest. A virus requires a host cell for replication which can include fertilized eggs, animals, or tissue culture cells. Customers work with attenuated strains of tissue culture cells and the viruses that infect humans. Aseptic sampling techniques, virus production signatures, and sampling points are also discussed.
- **Microscopy Course** – Customers prepare slides of biological agents, examine them under a microscope, prepare gram stain and spore stain slides, and determine if an unknown powder contains a biological agent. Instruction includes identification of *Bacillus anthracis* spores, differentiating between baking soda and *B. anthracis* spores, and identifying the spores when mixed with flour.

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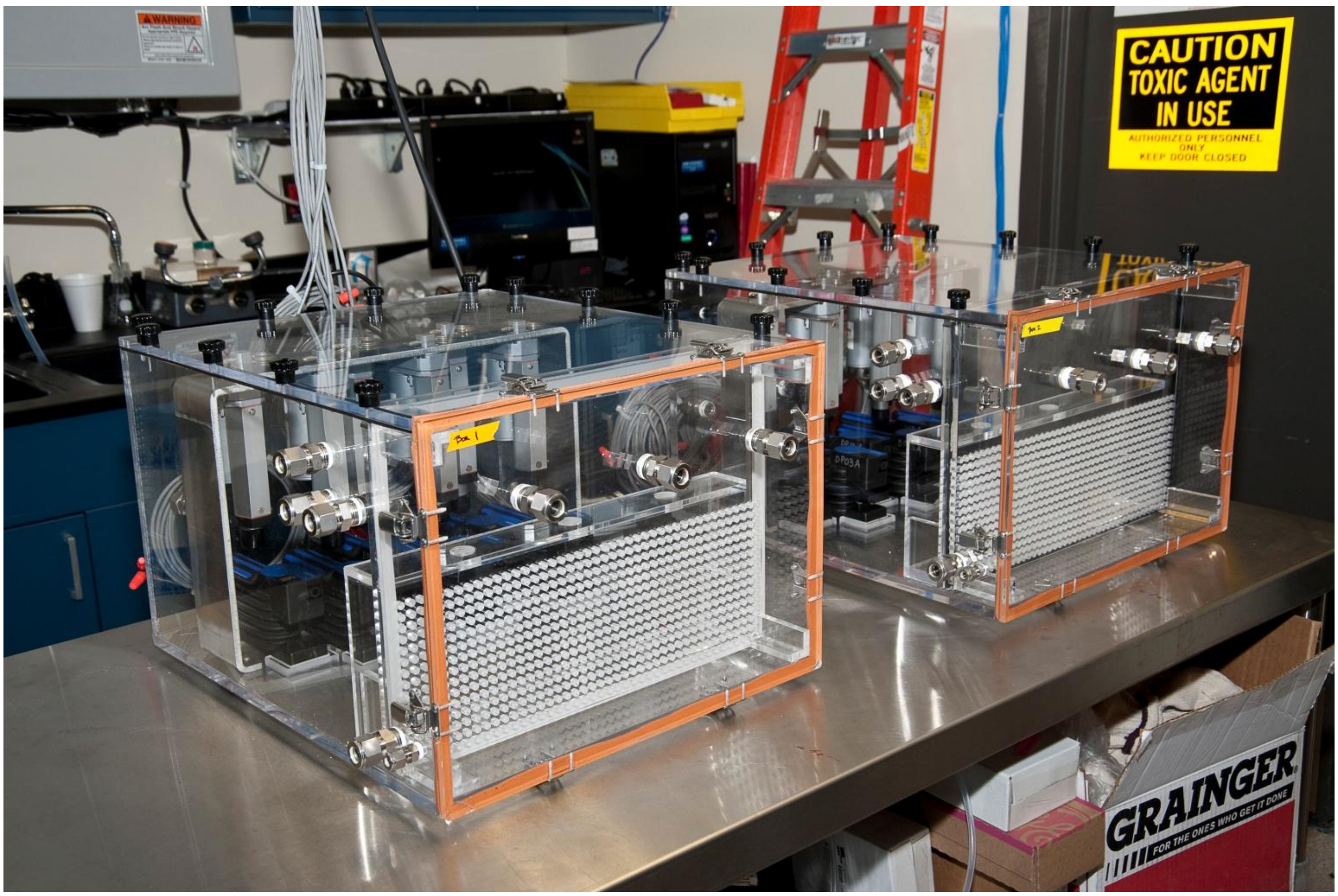
Section 5

Chemical Test



Capabilities

Reginald Kendall Combined Chemical Test Facility

Chemical Testing Overview

U.S. Army Dugway Proving Ground (DPG) is the nation's chemical and biological Major Range and Test Facility Base (MRTFB) and is the Army's first choice to test and evaluate (T&E) chemical defense equipment and systems while providing technical expertise to combat emerging chemical threats.

State-of-the-art laboratories located in the Combined Chemical Test Facility (CCTF), unique test fixtures, custom-built test chambers, and approximately 250 square miles of outdoor test grids, provide test officers excellent facilities to rigorously evaluate the functionality of individual collective protective equipment (IPE), collective protection equipment (ColPro), chemical point detectors, and the decontamination survivability of military equipment contaminated with chemical warfare agents.

The West Desert Test Center's (WDTC) unique facilities and experienced staff of scientists, test officers, chemists, engineers, and technicians, provide a full range of chemical T&E services – ranging from established protection, detection, and decontamination test programs through the development of one-of-a-kind test capabilities – to meet customer requirements for new or developmental products.

WDTC chemical test programs are divided into the following commodity areas:

- Individual Protection Equipment (IPE)
- Collective Protection Equipment (ColPro)
- Contamination Avoidance
- Decontamination Testing

Test officers are the primary customer point-of-contact (POC) and have overall responsibility for test planning, scheduling, financial management, implementation, and reporting of results. The test officer assembles a cross-functional team for each test project to tap the synergy of scientific and technical experts from multiple WDTC divisions.

The WDTC has the inimitable capability to develop methodologies for chemical testing and evaluation for new or future technologies. When a customer requests a test program that is beyond current

WDTC capabilities, Chemical Test Division staff will develop new strategic plans and test methodologies to fulfill the requirements.

Chemical test challenge material can be disseminated in liquid, vapor, and aerosol form in controlled test environments or in field testing with chemical simulants, battlefield interferents, and toxic industrial chemicals (TIC). The tables below lists some representative agents, simulants, and interferents used as challenge material during chemical tests: (**Note: List is not all-inclusive**)

Class	Symbol	Name
Nerve	GA	Tabun
Nerve	GB	Sarin
Nerve	GD	Soman
Nerve	VX	Persistent nerve agent
Blister	L	Lewisite
Blister	H, HD, HT	Sulfur mustards
Pulmonary	CG	Phosgene
Blood	CK	Cyanogen chloride
Blood	AC	Hydrogen cyanide

Class	Symbol	Name
Simulant	DEEP	Diethyl ethylphosphoate
Simulant	DMMP	Dimethyl methylphosponate
Simulant	MeS	Methyl salicylate
Simulant	SF6	Sulfur hexafluoride
Simulant	TEP	Triethyl phosphate
TIC	Cl_2	Chlorine
TIC	NH_3	Ammonia
Interferent	FG	Fog oil
Interferent	JP-8	Jet propellant 8

Chemical Surety

Chemical Test Division personnel comply with Army Regulation 50-6, Chemical Surety, by actively participating in a system of reliability, safety, and security control measures designed to protect government and civilian employees, the local population, and the environment. The Chemical Surety Program includes: mandated compliance with safety, operational, and technical procedures; physical security to prevent unauthorized access or use of chemical agents; personnel reliability assessments and training; safety air monitoring; and proper chemical agent storage, handling, maintenance, transportation, accountability, and disposal. Chemical Accident or Incident Response and Assistance (CAIRA) operations is a system of methods, personnel, and equipment that responds to accidents or incidents involving chemical warfare agents, and includes quarterly drills by emergency response forces.

Individual Protective Equipment

The Individual Protection Equipment (IPE) group within the Chemical Test Division conducts developmental and operational chemical testing on fabrics, materials, gloves, footwear, and protective masks/ensembles. Tests are conducted within the Combined Chemical Test Facility using custom-built swatch and system test fixtures and chambers.

Swatch cell cups inside Dugway Fixture

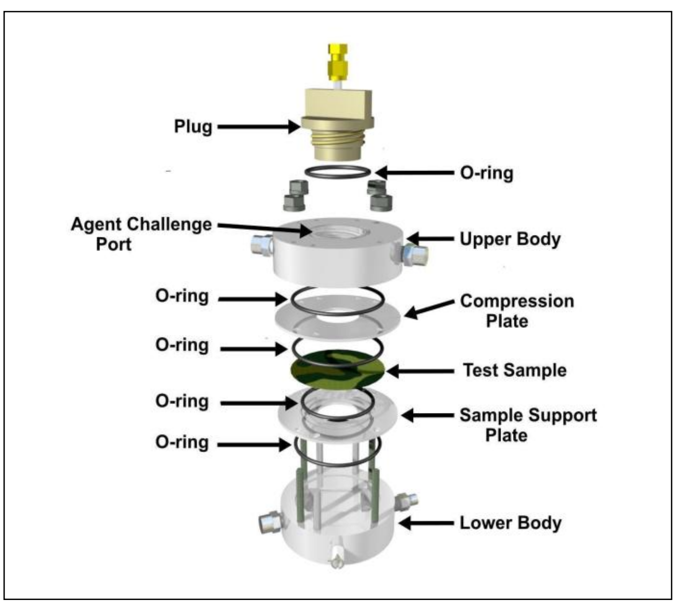
Test materials and components are subject to liquid and vapor challenges with chemical warfare agents (CWA), toxic industrial chemicals (TIC), and battlefield contaminants under fume hoods or inside environmentally-controlled chambers.

IPE Swatch Tests

Scientists and test officers develop programs and methodologies to test IPE materials, including new or fielded swatches of uniform fabrics, or associated IPE materials, such as butyl rubber or silicone-based materials that are used in protective masks.

Project chemists challenge materials with chemical agents utilizing specially-designed swatch test fixtures, such as the Aerosol Vapor Liquid Assessment Group (AVLAG) fixtures (3), which hold up to 30 swatch test cups apiece. Each cell cup holds a two-inch diameter swatch of test material. While liquid challenges are the primary swatch test method in AVLAG, chemists recently developed the capability to conduct vapor permeation challenges in new test fixtures.

Chemical agent challenges can be performed in a convective mode for air permeable materials, dual-flow mode for impermeable materials, or in a static cell mode, depending on the test requirements. Chemical technicians may also conduct penetration and permeation tests of materials challenged under tension using specifically-designed mandrel and expulsion test fixtures.



Exploded diagram of a swatch test cell

Test materials can be in a new or used condition, or pre-treated with contaminants, such as simulated sweat, simulated salt water, diesel fuel, decontamination solution (DS2), aqueous film-foaming foam (AFFF), or other substances that may be encountered by the warfighter.

Liquid drops (10 g/m² contamination density) of chemical agent are applied manually or by an automatic dispensing system to test materials in environmentally-controlled (temperature, humidity, airflow) test fixtures or under ambient conditions within a certified fume hood.

A swatch test project may vary in the number of

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trials with total swatches tested, treatments, and agents identified in the test plan. Positive and negative quality control tests are used to detect any variation in swatch performance, testing processes, and analytical procedures. Swatch testing can be performed on material to determine the effects of storage under various environmental conditions, such as arid, tropical, and arctic climates.

Bubbler systems and solid sorbent tubes (SST) are used for sample collection (0.5 µg/mL minimum detection limit) in near real-time. Sample analysis may be performed by gas chromatography (GC), liquid chromatography/mass spectrometry (LC/MS), or with MINICAMS® (miniature, automatic, continuous air-monitoring system).

MINICAMS®

Swatch test data collected and analyzed may include:

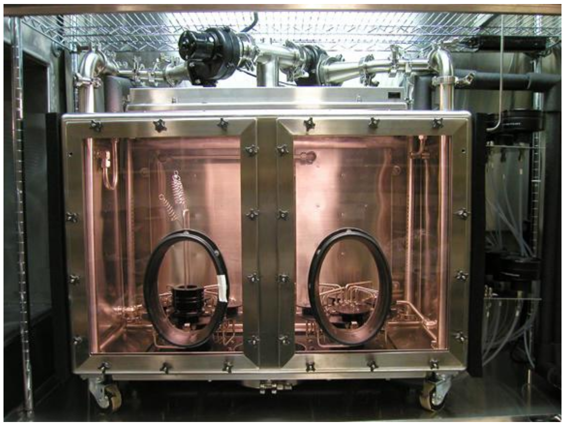
- Air permeability
- Treatment applied to each swatch
- Temperature and relative humidity
- Airflow
- Agent type and purity
- Number of drops applied to each swatch
- Positive and negative control results
- Bubbler data: time interval, minimum detection limit, agent concentration, agent mass
- Concentration X time (CT) by bubbler interval
- Cumulative CT across bubbler intervals
- Mass loss and adsorption of agent on swatch materials and test fixture components

IPE System Tests

System tests are conducted to obtain data on individual breathing equipment (masks), protective handwear and footwear, and to characterize resistance to convective penetration or diffusive permeation when exposed to a liquid or vaporized chemical agent. See **Simulant Agent Resistant Test Manikin (SMARTMAN)** for a description of individual breathing equipment test capabilities.

Protective handwear or footwear may be air-permeable, semi-permeable or impermeable; single or multi-layered composites; or inert, sorptive, or reactive. Test items can be new, used (e.g., worn for 15-30 days) or pre-treated with contaminants encountered in the battlefield, including simulated body fluids, petroleum, oil, and lubricants (POL), decontaminants, seawater, and munitions residue, and may be tested wet or dry. The number of test items used for each trial is determined by user-defined requirements in the test plan.

Test items are secured to custom-built fixtures—simulated human hand or foot form—and placed inside an environmentally-controlled exposure chamber where internal pressure of the handwear/footwear is regulated to be neutral, negative, or positive.



Glove and boot fixture

The glove system test fixture features a stainless steel enclosure, hand forms, auto-dispenser applicator, and sample collection system. The test fixture houses two carousels for glove testing with four hand forms each, allowing eight gloves to be tested at the same time. Stainless steel hand forms simulate a 50^{th} percentile male human hand in size and shape and are composed of flexible-spring digits that facilitate glove donning and doffing.

The test fixture is elevated above the floor of the fume hood to ensure proper airflow in and around the test fixture. The fixture can maintain a 24-hour control of operating temperatures, relative humidity (RH), chamber differential pressure (ΔP), glove ΔP, chamber airflow, and glove airflows.

Liquid droplets (≈1-10 µL neat agent; ≈5-µL of thickened agent) are placed on a test item (≈10 g/m² contamination density) at predetermined contamination areas. Vapor challenges of distilled sulfur mustard agent (HD) can range from 5-50 mg/m³ and a vapor challenge of sarin (GB) can range between 100-4000 mg/m³. Vapor concentrations are measured by near real-time analyzers, such as sulfur/phosphorus analyzers and MINICAMS®.

Conditioned airflow through the test chamber maintains temperature (0^{o} to 50^{o}C) and RH (20% to 90%) during a test. Effluent air from each test item is sampled and analyzed to detect the amount of agent penetrating the test item as a function of time.

Sample collection and analysis instrumentation includes MINICAMS® and solid sorbent tubes followed by GC analysis with flame photometric detection (FPD) or flame ionization detection (FID). Test data may include a case narrative, chain-of-custody, inspection results, lab notebook pages, charts/graphs of environmental conditions, charts/graphs of breakthrough concentrations, and analytical results.

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Individual Protection Ensemble Mannequin System (IPEMS) – Preview the Future

The Individual Protection Ensemble Mannequin System (IPEMS), expected to be operational by the end of 2012, will be a one-of-a-kind capability at the West Desert Test Center to test and evaluate (T&E) the effects of simulated human movements and physiological conditions during tests of protective clothing and equipment challenged with chemical warfare agents (CWA). The IPEMS will be housed in the newly-renovated Laboratory Building 4165 at the Combined Chemical Test Facility.

While current full ensemble testing utilizes the Man-in-Simulant Test (MIST) protocol that offers the benefit of human movements, simulants can only mimic a few characteristics of chemical agents. MIST does provide end point data for simulant breakthrough but lacks critical information on when, where, and how breakthrough occurs.

A free-standing, self-balancing robotic mannequin will simulate soldier motions and activities (including running up to 4 mph) and allow for system-level T&E of IPE ensembles against CWA and simulants at a wide range of challenge concentrations. In addition to the programmable mannequin, the IPEMS will include a live agent exposure chamber with environmental controls (temperature, relative humidity, airflow) and capable of sustaining up to a 100 mg/m³ challenge of sarin (GB) or sulfur mustard (HD) up to 24 hours.

The mannequin, based on the 50th percentile male soldier, will perform reproducible motion exercises with real-time sensing of chemical agent breakthrough, heart rate, and other physiological characteristics. The mannequin body surface will feature 17 separate hard-shell regions and 14 independent thermal zones with 32 chemical sensing ports to provide near real-time under-ensemble sampling to monitor agent penetration. Simulated human test conditions will include:

- Mobility – Programmable and reproducible robotic motions simulate the full range of warfighter motion
- Body temperature and perspiration – Moisture-permeable fabric or metal shell transfers body-temperature water from the mannequin core through tiny pores on the "skin"
- Respiration – A mechanical lung system simulates breathing movements of the chest.
- Skin – Moisture-permeable fabric simulates the feel of skin and protects mannequin circuits and systems from exposure to chemical agents

Sponsored by the Product Director Cross Commodity Advanced Threats and Test Infrastructure (PD CCAT&TI), MRIGlobal is the prime contractor for the IPEMS project, and is responsible for systems engineering, test planning, sensor selection, material compatibility analysis, system commissioning, and program management. Project subcontractors include: Boson Dynamics, responsible for robotic mannequin design and fabrication; Measurement Technology Northwest, development of mannequin physiology; Sensor Research and Development Corporation, mannequin chemical sensor development; Smith Carter CUH2A, containment chamber design; and HHI Corporation, responsible for construction and installation of the exposure chamber.

Collective Protection Equipment

Collective protection equipment (ColPro) may be permanent or temporary shelters, and include tents, vans, and trailers (transportable); vehicles, ships, and aircraft (mobile), or established buildings. Shelters are typically used for command/control operations, medical units, and rest/relief areas, and are designed to provide sustained, protection while maintaining a toxic-free environment against chemical and biological hazards.

The Chemical Test Division (CTD) conducts a full range of acquisition testing of ColPro components and systems, using chemical warfare agents (CWA), simulants, and toxic industrial chemicals (TIC) which includes:

- Barrier materials swatch and coupon off-gassing testing
- Component testing of ColPro closures and seams
- Air filter component and air filtration system testing
- Full-system tests in environmentally-controlled chambers using agents and simulants; tests include ColPro verification testing, wind-driven challenge tests, and entry/exit tests
- Outdoor field testing of full systems using CWA simulants or TICs

ColPro components/systems can be subject to tests using select battlefield contaminants (BFC) in solid (including particulate matter), liquid, vapor, paste, or aerosol form. BFCs used in testing include: liquid jet propulsion fuel-type 8 (JP-8), N,N-diethyl-meta-toluamide (DEET), wasp spray, bleach, and obscurant smoke (JP-8 exhaust and fog oil) among others. Air filters are currently tested with obscurant smoke contaminants in vapor and aerosol challenges.

A traceable simulant selection process has been defined, based on physical properties and usability. The process has been used to select simulants for sarin (GB), soman (GD), and distilled mustard (HD) for permeation testing of select filtration and barrier materials. This process can be followed to select appropriate simulants for future filtration and barrier materials.

By using design-of-experiment techniques and testing materials to obtain permeation curves, the data collected from barrier materials, closures, and air-purification components are used to develop, verify, and validate models for agent-to-simulant relationships (ASR) that correlates between CWAs and their simulants.

Current Joint Expeditionary Collective Protection (JECP) component-level ASR test data are used to develop empirical-based modules for the JECP System

Performance Model (SPM). The SPM is a software model-based testbed that allows test officers to simulate operational environments for JECP applications across a range of battlefield conditions. CTD scientists generate empirical and semi-empirical models in support of SPM development, such as airflow mapping. See **Collective Protection Airflow Mapping** for additional information.

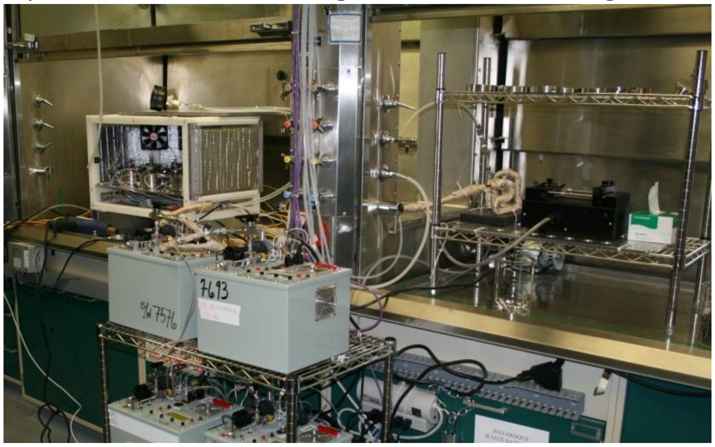
ColPro Component Tests

In addition to barrier protection, the core functions of each ColPro system include air purification, an entry/exit mechanism, and creating positive pressure against the ambient atmosphere within the toxic free area (TFA) to prohibit contaminated air infiltration through leak paths.

Collective protection closures, seams, air filters, filter blower units, and air filtration systems are evaluated for effectiveness and to identify weaknesses of components in stand-alone test processes. Tests provide penetration and protection data over time, based on real-time agent/simulant/TIC challenges and near real-time permeation/penetration measurements.

ColPro Swatch Tests

ColPro barrier material swatches, including new, seamed and patched material swatches, are evaluated for baseline (new) chemical-biological protection as well as degradation due to usage, field environments, contaminants, and storage.



ColPro swatch test

ColPro swatches may include tent fabrics and liners, airlock barrier materials, air filter fabrics, gasket materials, neoprene swatches, and butyl rubber, which are challenged with chemical agents, simulants, or TICs, in new or used form, or after treatment with a BFC. Swatches from barrier protection components can be tested using either the standard aerosol vapor liquid assessment group (AVLAG) swatch fixtures or with the near real-time Swatch Including Filter Test (SWIFT) system, which can accommodate either dual-flow or convective flow swatch cups. Materials may undergo accelerated aging in environmentally-controlled chambers to establish shelf life requirements prior to being cut into swatches for testing.

Swatch material is exposed to varying vapor or liquid droplet concentrations of agent, simulant, or TICs under controlled temperature or temperature/relative humidity conditions. Affluent air is analyzed to measure the amount of analyte penetrating the barrier swatch material, as a function of time. Testing is conducted using near real-time (NRT) instrumentation to determine the breakthrough time and concentration required to calculate the diffusion coefficient for the barrier material.

Liquid CWA drops (1 µL) are dispensed in equally-spaced patterns on each swatch to achieve a surface density ranging from 1 to 20 g/m^2. Vapor challenges to swatches, which vary by agent/simulant, are measured by Gasmet™ Fourier transform infrared (FTIR) gas analyzers (or with MINICAMS® using a measured sample loop) and disseminated in concentrations ranging from 0.01 mg/m^3 to 5000 mg/m^3. MINICAMS® equipped with flame photometric detectors (FPD) and flame ionization detectors (FID) for low- and high-level concentrations, provide NRT sample collection/analysis of vapor penetration.

The SWIFT system is also used for coupon off-gassing, filtration fabric permeation, and small-scale filter permeation tests. See **ColPro Small-Scale Air Filtration Tests** and **Swatch Including Filter Test (SWIFT) System** for additional information.

Seams and Closures Tests

The Novel Closures Test Fixture (NCTF) is a unique capability that is available to test and evaluate closures and seams designed as openings for ColPro structures that allow personnel entry/exit, and positive pressure and system environmental control equipment attachments. A closure/seam in a barrier material – a production representative with the same size (or scalable), shape, and dimensions of a fielded closure – is embedded in a barrier liner composed of fielded ColPro liner material and challenged with agents or simulants in a controlled chamber.


Novel Closures Test Fixture

The NCTF is a rectangular, rigid-aluminum frame, open on the top and bottom, with an aluminum support frame positioned in the center of the structure adding support to the top and bottom. The fixture frame allows for the length of the fixture to be adjusted to accommodate various sizes of closures.

Vapor-tight polyethylene liners, capable of maintaining differential atmospheric pressures, are installed lengthwise on each side of the test fixture creating two fully-enclosed compartments separated by a barrier wall in which the test closure is embedded. The barrier wall is mounted and sealed to the test fixture with the only opening being the embedded novel closure or seam to be tested and evaluated. The length of the test fixture is limited to a minimum of six feet and a maximum length of 14 feet.

Analytical instrumentation provides NRT response and analysis, combining MINICAMS®, FTIR gas analyzers, point detectors, and cumulative sampling devices in both the TFA and dissemination compartment to accurately evaluate the chemical resistance of the closure or seam. See **Novel Closures Test Fixture** for additional information.

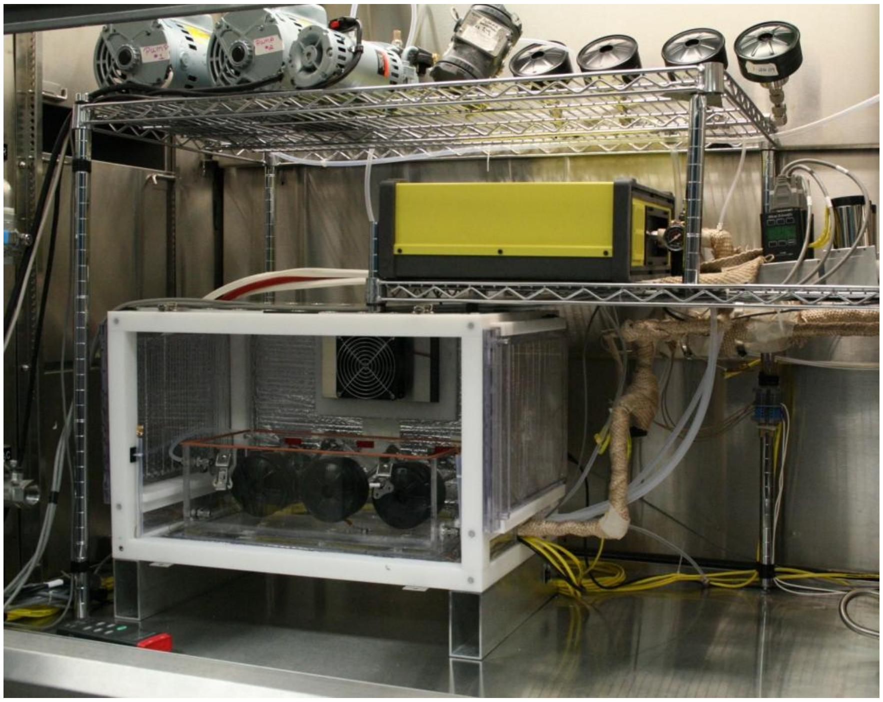
ColPro Small-Scale Air Filtration Tests

Small filter test projects are designed to determine agent and simulant penetration rates and are used to develop, verify, and validate agent-simulant relationships (ASR) for future filter testing. In addition, scientists develop empirical models for input into the JECP System Performance Model (SPM) and determine a scalability relationship between small filters and larger filters used in ColPro shelters. For example, the M40 respirator filter can be characterized with the results scaled to represent the larger M98 filters used in ColPro air filtration systems. Test programs may include air filter performance in relationship to airflow or exposure to battlefield contaminants.

The Dugway Fixture (^{d}FIX), a component within the SWIFT system, features a removable tray system that accommodates the small-scale air filter fixture to test filters (or tubes with carbon filtration media)

such as the FR-C2A1 gas filter cartridge. Small air filters may be challenged with test materials such as CWA, simulants, BFCs, and toxic industrial chemicals (TIC) within the fixture.

Small filters may be attached to ports mounted within the vapor-tight acrylic test fixture and inserted into the ^{d}FIX. A syringe pump (or custom-built sparger-type disseminator for larger concentrations) disseminates test materials into the airstream that may range from 1 to 5000 mg/m^3 as per required challenge material and as defined within a test plan.


Small air filter test

Temperature in the ^{d}FIX is controlled by a thermoelectric heating/cooling unit and ranges from approximately 5^{o} to 55^{o} C (±5°C). A liquid chromatography (LC) pump is plumbed into the airstream to add humidity (up to 85%) inside the test fixture. A mixing chamber thoroughly mixes the test material, air, and water vapor. Gasmet™ FTIR spectrometers or MINICAMS® are used to monitor the challenge airstream before it flows into the test fixture.

A vacuum pump draws controlled airflow (≈100 to 300 mL/min.) through each filter identical to the direction of airflow in an operational filter. MINICAMS® sample for breakthrough in near-real time for each filter with challenge concentrations measured by Gasmet™ analyzers. MINICAMS® are also used as secondary challenge referees and to monitor downstream effluent concentrations.

Data collected and analyzed during small-filter testing may include:

- Challenge concentrations from Gasmet™ and MINICAMS®
- Effluent concentration from MINCAMS®
- Time to breakthrough
- Permeation curves
- Temperature and humidity
- Mass of test material delivered by the disseminator
- Mass of water delivered by the humidifier
- Airflow
- Mass of filter before and after challenge

Full-Scale Air Purification Components/Systems Tests

The Advanced Air Purification Test Fixture (AAPTF) is used to test large ColPro air filters and full-scale air-filtration devices with airflow rates ranging from 60 to 2000 cfm. Additional blowers can be added for testing of larger systems. The fixture's modular design allows for multiple configurations.

TOC

The AAPTF operates within an environmental test chamber (ETC), which can maintain an average negative differential pressure of 0.5 inches of water gauge (iwg). Temperatures within the ETC may be controlled from -10° to 55° C; relative humidity (RH) may be controlled to range from 5% to 48% at temperatures above 5° C with higher RH levels maintained at lower temperatures (≈5°C). Filters inside the AAPTF may be challenged with vapor simulants, CWAs, TICs, and BFCs.

The AAPTF has been used to: test M48 and M98 filters using GB and GD; determine the scalability relationship between C2A1 and M98; and to measure real-time permeation curves for agents and their corresponding simulants. See **Advanced Air Purification Test Fixture** for a description of the system.

ColPro Full-System Tests

The WDTC has unique facilities to test whole collective protection systems with static challenges using chemical or biological (CB) agents or simulants, dynamic challenges in a controlled environment using simulants, or to conduct operational field testing using simulants. Chemical and biological tests of ColPro systems are a collaborative effort between the Chemical Test Division and the Life Sciences Division.

ColPro systems under test (SUT) can be evaluated for entry/exit procedures, threat-representative challenges, and purge testing of systems. Scientists and test officers measure CB challenges in real time and vapor/aerosol penetration in NRT.

Entry/exit tests determine whether a ColPro system allows entering, exiting, and resupplying to occur at a specified rate in a contaminated environment without introducing quantities of hazardous contaminants into the TFA and exposing unmasked occupants. An entry/exit test consists of exposing the SUT and test personnel to CB simulants while performing multiple replications of each variation in entry/exit procedures, including: procedures for ambulatory or litter-borne patients using a medical shelter; ensemble (e.g., masks, overgarments, hoods, gloves, boots, etc.) variations worn by crew members; and variations in a doffing location, such as in open

air, an airlock, or an enclosed contamination control area. (Note: Test participants must wear appropriate personal protective equipment including disposable, impermeable protective suits, gloves, boots, and eye and breathing protection.)

Static challenges for ColPro verification tests provide test officers with data on how each ColPro system resists agent/simulant penetration or permeation before placing the system under a dynamic wind-driven challenge. The static challenge tests are designed to examine engineering factors and the design of the system.

Dynamic testing subjects the SUT to realistic CB simulant challenges inside a chamber where vapor or aerosol is disseminated into a controlled airflow under ambient wind speeds and environmental conditions, while a wide range of instruments characterize the challenge inside and outside the SUT. Dynamic tests are normally conducted in a wind-tunnel facility, such as the **Joint Ambient Breeze Tunnel (JABT)**. The JABT is approved for disseminating CB simulants in aerosol and vapor form, with the ability to generate wind speed up to 6.0 m/s (13.42 mph). The facility allows for dynamic chamber and entry-exit simulation tests using ambient environmental conditions to include personnel entry/exit through airlocks to analyze both mechanical transfers of liquid simulant and vapor migration into the TFA during processing.

Collective Protection shelter inside Joint Ambient Breeze Tunnel

The Materiel Test Facility (MTF) Multi-Purpose Chamber and the East and West chambers in Building 3445 are certified for chemical agent and simulant dissemination and may be used to evaluate a ColPro system's overpressurization capability, system purging, airflow, leakage, and static challenge verification testing (SCVT). Tests may include personnel entry/exit through airlocks to analyze both mechanical transfer of liquid simulant and vapor migration into the TFA during processing.

The test grid is permitted for open-air CB simulant and TIC releases (DPG has available over 35 approved simulants) in a desert and mountainous environment for stationary and mobile ColPro systems. Dissemination of CB simulants, TICs, and BFCs in liquid, vapor, aerosol, and powder form during operational field trials can be initiated by explosion, mobile spray units, fixed stacks, and aerial spray. See **Field Dissemination Systems** for additional information.

ColPro systems are challenged with simulant vapor clouds and analysts compare the simulant challenge concentration to simulant breakthrough inside the TFA. Targeted CT (concentration X time) levels that simulate a threat scenario generally range between 5000 mg-min/m³ and 20,000 mg-min/m³.

TOC

Test officers utilize a wide variety of instrumentation during chamber and outdoor field trials to measure environmental conditions, real-time monitoring (RTM) of challenge concentrations, and NRT sampling and monitoring of total challenge and breakthrough concentrations.

Challenge concentration monitoring instrumentation includes: MINICAMS® capable of measuring vapor concentrations from 10 to 1000 mg/m³; Gasmet™ gas analyzers with a detection range of 1 to 5000 mg/m³; sequenced solid sorbent tubes (SST) with a detection range of 0.001 to 10 mg/m³; and ppbRAE® gas/chemical detectors (1 to 9,999 ppb). Breakthrough instrumentation detects concentrations at the meiosis level including MINICAMS® (detection range 0.001 to 10 mg/m³), SSTs, and ppbRAE® detectors.


Meteorological instrumentation for ColPro full-system test inside JABT

Standoff detectors, such as infrared (IR) cameras, monitor vapor cloud movement and map the cloud from the dissemination point to the target SUT, measuring and recording real-time data such as average length, width, and uniformity of the cloud. Vapor cloud monitors have a detection range of 25 to 130 mg/m³. See **Chemical Cloud Tracking System** for more information.

Meteorological instruments, such as Portable Weather Information Display Systems (PWIDS), provide a vertical profile of environmental conditions, including wind speed, wind direction, atmospheric pressure, relative humidity, temperature, and precipitation. In addition, meteorology/climatology test support is utilized from test preparation to post-test analysis, including general and test-specific weather forecasts and warnings and test range meteorological support infrastructure.

Referee instrumentation placed inside the SUT monitors entry/exit portals, work areas, ColPro equipment intake and exhaust, and other key locations. A ColPro system that uses overpressure is evaluated during system-level testing using differential pressure sensors during entry/exit and through structural openings. Low-pressure alarms provide visual indication of overpressure plus visual and audible alarms for detection of the low pressure.

Contamination Avoidance

Contamination avoidance is the warfighter's first defense against adversarial use of chemical weapons, initiated by early detection, location, identification, and confirmation of chemical hazards in the field of operations. Successful contamination avoidance minimizes disruptions to a unit's mission by eliminating unnecessary time in various protective postures and reducing decontamination activities.

The West Desert Test Center (WDTC) utilizes the expertise of scientists, test officers, chemists, engineers, and technicians to conduct a full range of developmental and operational test and evaluation (T&E) programs for chemical point and standoff detectors. Whether a detector is a candidate for acquisition or is currently under development by a customer, the WDTC's laboratories, fixtures, test chambers, and outdoor test grid are used to evaluate detector performance when challenged with chemical warfare agents (CWA), chemical simulants, toxic industrial chemicals (TIC), and battlefield interferents.

Dugway can also provide experienced chemical test staff and support personnel, plus test materials and referee systems, to support off-site (safari) test programs.

Detector Laboratory Tests

WDTC scientists and test officers utilize laboratories for small-scale detector testing which can provide a customer with quick, preliminary data sets of a unit's durability, identification algorithms, and response to various chemical/contaminant combinations, or can facilitate the development of a detection library. This may assist a customer in modifying the detector's capabilities prior to further developmental testing.

Testing and characterization of chemical point detectors is conducted within glove boxes located in the Combined Chemical Test Facility (CCTF) and Bushnell Materiel Test Facility (MTF). Environmentally-controlled fixtures allows for subjecting a detector unit to extremes in temperature (-29^{o} to 49^{o}C) and relative humidity (<5% to >80%) while performing challenges with chemical agents and simulants.

Laboratory tests of portable chemical identification and analysis instruments

Lab test projects may include:

- Verification of upper and lower identification thresholds of CWA/TICs
- Durability of detector units
- Identification capability after exposure to high concentrations of chemicals
- Effects of identification performance under varying environmental conditions
- Analysis of common battlefield contaminants (e.g., diesel fuel, gasoline, brake fluid, paint)

- Complex background effects on detector unit performance
- Validation of CWA identification using dilute CWA solutions

The Immersion Chamber is a laboratory test fixture that was designed and fabricated at Dugway by scientists and engineers. The Immersion Chamber allows testers to evaluate the detection performance of multiple detector systems by challenging them side-by-side with a broad range of chemical vapor concentrations and interferents, including initiating on-demand challenges. (For more information, see **Immersion Chamber**.)

Point and Standoff Detector Test Fixtures

Test fixtures located within the MTF allow for detector performance testing under ambient or environmentally-controlled conditions. Test officers can subject point or standoff detectors to varying concentrations of chemical agent or simulant vapors to test a unit's identification, response time, and functionality prior to field testing.

JCAD units under test inside an MTF glove box

Chemical Point Detector Tests

Portable point chemical agent detector units (DU) are tested within environmentally-controlled, custom-built fixtures located in MTF chambers permitted for CWA and simulant dissemination. The Closed System Chamber (CSC) allows for the dissemination of a variety of chemical agents, including tabun (GA), sarin (GB), soman (GD), cyclosarin (GF), distilled mustard (HD), nitrogen mustard (HN3), lewisite (L), and persistent nerve agent (VX). A single fixture can test up to nine detector units; the CSC has been used for testing the Joint Chemical Agent Detector (JCAD) M4, M4E1, and M4A1 units.

The environmental control system consists of heater/chiller units and a liquid chromatography pump to adjust water vapor content (WVC). The system maintains the chamber and airstream at a constant temperature and holds the airstream at a constant humidity. During test trials, agent is disseminated at pre-determined target concentrations and challenge times (generally 10 to 45 minutes for blister and nerve agents), under varying temperatures (-5^{o} to 50^{o}C) and WVC (0 to 32 g/m^3).

The test fixtures are thermally-jacketed glove boxes that house the DUs, radial distribution manifolds (RDM), temperature and humidity probes, and video cameras. Pre-heated air is delivered through an evaporation tee and chemical agent is disseminated through tubing and fittings and mixed with air to maintain the desired challenge concentration. Airflows from 5 to 20 L/min and infusion rates of 0.01 to 1.0 µL/hr are typically used to produce target concentrations of agent or simulant of 0.0001 to 30 mg/m^3.

The referee system consists of MINICAMS® (miniature, automatic, continuous air-monitoring system) which monitor the concentration of CWA in the airstream at the RDM. Data collection software collects and records all DU response information, environmental data, and referee data for each unit.

Test data collected and analyzed may include:

- Agent dissemination on and off times
- Agent concentration
- Initial alarm start time
- Final alarm start time
- Time to alarm (elapsed time from agent dissemination to alarm)
- Cleardown time (elapsed time from agent dissemination off to no alarm)
- Agent, identification and alarm strength levels
- Temperatures and WVC within the chamber and manifolds

A test officer prepares for a JCAD test in the MTF control room

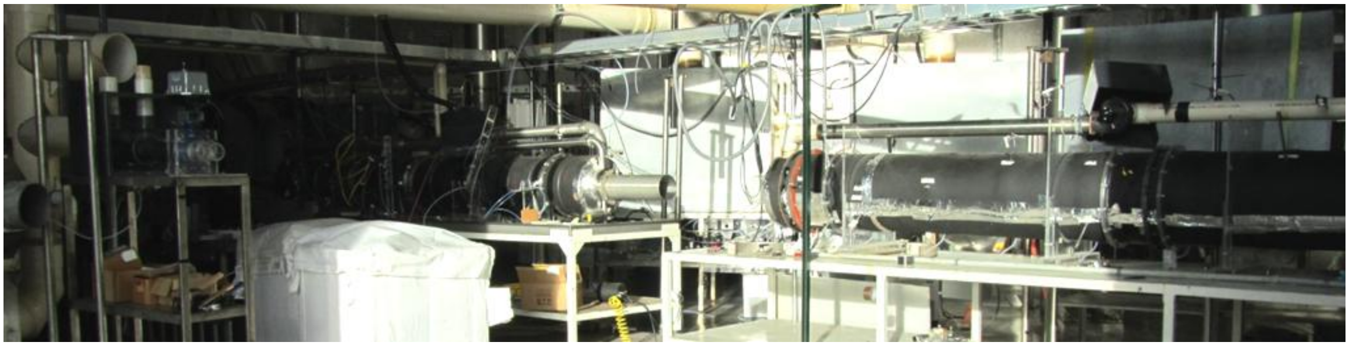
Chemical Standoff Detector Tests

Standoff chemical agent detector systems may undergo testing with chemical agents, simulants, and battleground interferents within custom-built test fixtures located in the MTF Multi-Purpose Chamber.

The Vapor Test Chamber (VTC) and the Interferent Test Chamber (ITC) are 16.4-foot long cylindrical chambers that maintain a vapor or interferent cloud under controlled ambient temperatures. Analyte CWA vapors are disseminated through a controlled-airflow system which provides constant recirculation within the chamber. Vapor is contained within each chamber by a 6-inch zinc selenide window on one end and an air curtain on the opposite end.

Analyte vapor concentrations are continuously monitored by MIRAN or Gasmet™ portable gas analyzers. Fourier transform infrared (FTIR) spectroscopy referee instrumentation collects the infrared (IR) spectra of chemical challenges.

Detector units can be tested at a single concentration-pathlength (CL) with agents such as GB, GD, HD, and Lewisite, and simulants such as triethyl phosphate (TEP) and acetic acid. Agent/simulant may be disseminated at concentrations ranging from <1 to 5600 mg/m³, depending on the chemical properties of the agent or simulant.



Vapor Test Chamber and Interferent Test Chamber inside MTF Multi-Purpose Chamber

Detector systems under test (SUT) are positioned to stare through two chambers within a calibrated blackbody source located on the opposite end of the test fixture. A set of front-surface, unprotected gold-coated mirrors redirects the IR signal from the blackbody, modified by the IR signal of the CWA vapor, into the entrance aperture of the SUT.

A trial detection opportunity is a five-second period during which an SUT is allowed, using optics, to sample the IR signal composed of the agent/simulant/interferent within the chamber and blackbody and to activate the unit alarm.

Test trial data collected and analyzed for standoff detectors may include:

- Chamber temperature and agent/simulant/interferent concentration levels
- Blackbody temperature
- Time to alarm
- IR spectral data from referee FTIR and corresponding CL and temperature differentials
- Detector unit alarm data, including number of alarms and agent class identification
- Mirror positions
- Test incident reports from unit malfunctions

Detector Whole-System Tests

Detection systems designed for a specific platform, such as the Chemical Biological Mass Spectrometer, Block II (CBMS II) for the Stryker Nuclear Biological Chemical Reconnaissance Vehicle (NBCRV), may undergo testing with chemical agents, simulants, battleground interferents, and liquid toxic industrial chemicals (TIC) within a Dugway-designed test fixture located in the MTF.

The test fixture features an automated dissemination system that precisely deposits a quantified amount of sample in an exact location on a silicone or other test surface to produce reliable test results. The fixture rotates the surfaces back and forth between the disseminator and the test probe in an automated manner which allows for reproducible test trials. Liquid test materials include chemical agents (e.g., GB, VX, HD, CS, CN), simulants (e.g., MeS, DEM), interferents (e.g., fog oil, DEET, JP-8), riot agents, or TICs (e.g., acetic acid, chloropicrin, dimethyl phthalate, parathion).

Stryker NBCRV equipped with CBMSII

The fixture contains test probes positioned upright in an agent-certified fume hood. A metal shield protects the liquid sampling portion of each probe. A metal plate beneath the two probes holds a segment of the silicone-sampling wheel. An automated syringe disseminates liquid drops (1.0 to 2.5 µL) to the center of a sampling wheel segment. The sample tray is raised upward by a pneumatic piston to contact each SUT probe with approximately 2.5 pounds of force (lbf) for up to five seconds. The sequence may be repeated up to two additional times. The number of challenges/trials and associated parameters will vary by test plan. Cameras installed inside the test fixture monitor dissemination and subsequent surface/probe interactions with the ability to view droplets as small as 1.0 µL.

TOC

The SUT probe samples the material and the alarm status (detection or no detection; alarm or no alarm) is recorded. Additional trial data collected and analyzed may include:

- Ambient air temperature and relative humidity inside the fume hood
- Agent/simulant/interferent/TIC used, mass, concentration, volume, and mass of spiked quality control samples
- Number of positive/negative responses
- Time to alarm and cleardown time
- Background and peak-level concentration levels
- Audible alarm/warning status, with substance identified
- Highest relative intensity while unit is in alarm state

Detector Field Testing

Dugway's unique terrain, climate, and outdoor test grids allow for detector field testing under operationally realistic conditions to determine a unit's effectiveness, suitability, and survivability for U.S. and allied troops. Individual field trials may run for up to 96 hours.

Detector field tests may be conducted on a single, instrumented test grid that allows vapor disseminations to be conducted without restrictions to wind direction, or may encompass multiple test grids throughout the range for multi-service operational tests. Detector systems may be tested in fixed locations or attached to vehicles traveling on predetermined routes. A wireless network allows data to be captured from remote locations.

Chemical agent simulants, such as acetic acid (AA), triethyl phosphate (TEP), methyl salicylate (MeS) and diethyl malonate (DEM), can be disseminated by fixed or mobile stacks, explosives, aerial spray, or by backpack spray systems. See **Field Dissemination Systems** for more information on dissemination methods.

Threat-representative vapor clouds can be released to provide detection opportunities for multiple detector units throughout the test grid(s). Released simulant may range from 1 to 500 kg per event. Challenge cloud concentration-pathlengths (CL) may range from 550 to 2500 mg/^{2}. Minimum cloud dimensions may be approximately 250 m in length, 250 m in width, and 30 m high. IR cameras are used to characterize the cloud size and position as a function of time.

A Chemical Cloud Tracking System (CCTS) tracks the cloud beginning at the release point and across the test grid through a system of passive standoff IR detectors, generating 3-D concentration maps in real time. The system merges data from multiple scanning Fourier transform infrared (FTIR) spectrometry sensors which mathematically reconstructs a 3-D concentration map from individual sensor information. See **Chemical Cloud Tracking System** for more information.

A suite of meteorological instrumentation is incorporated into field trials, including 32 m meteorological towers, portable weather information display stations (PWIDS), sonic detection and ranging (SODAR) systems, and multiple surface atmospheric measurement systems (SAMS). Data on wind direction, wind speed, temperature, and relative humidity (RH) at different locations and elevations can be used to model cloud development and path using a Second-order Closure Integrated Puff (SCIPUFF) model. On-site meteorologists monitor local Doppler radar systems to provide current forecast information to test officers. See **Weather Forecast Systems** for additional information.

Additional instrumentation may include ppbRAE photoionization detectors to record simulant concentration in parts per billion, and solid sorbent tubes (SST) for simulant identification and mass of simulant collected. Filter paper placed around the test grid may be used to referee ground deposition trials.

Test and referee data collected is processed and stored in the Test Data Management System (TDMS), and may include:

ppbRAE set up for field test

- Alarm data (time, azimuth, elevation, chemical identification) as collected in real-time by system operators or data-acquisition software
- Alarm data (time, azimuth, elevation, chemical identification) from electronic logs
- Dissemination methods and data, including total mass and concentration
- IR camera data: cloud images; cloud length, width, height, and centroid position (as a function of time); 3-D cloud model (as a function of time)
- Line-of-sight FTIR data (cloud CL as a function of time)
- CCTS data (cloud CL and cloud extents, as a function of time)
- Global Positioning System (GPS) data
- Meteorological data: temperature, RH, wind speed and direction, as a function of time and sensor location/elevation; vertical wind profile; vertical atmospheric temperature profile; vertical ozone concentration profile
- SCIPUFF model data

Near real-time data assessments are performed for the number of verified clouds detected by the system under test (SUT), operation data (amount disseminated), SCIPUFF model prediction data, PWIDs data and CCTS data. Position and alarm information is recorded for SUT fixed and mobile platforms. Time, space, and position information (TSPI) is collected every second and alarm events are recorded as they occur. TPSI data is collected from cloud referee equipment, and all TPSI, SUT and meteorological data is merged and used for subsequent analysis.

TOC

Decontamination Testing

U.S. military forces are afforded the best-available individual and collective protection equipment, and chemical, biological, and radiological (CBR) contamination avoidance technologies. However, despite a unit's ability to avoid or withstand a CBR exposure event, warfighters must quickly respond and mitigate the effects of personnel and equipment exposure by removing, absorbing, or neutralizing CBR contaminants while continuing to sustain operations.

Decontamination Pad

Warfighters and support units rely upon (and must have confidence in) decontaminants and decontamination application systems, plus the ability of mission-critical equipment, to withstand the rigors of contamination/decontamination processes.

Scientists and test officers at the West Desert Test Center (WDTC) provide a full range of CBR decontamination test programs to support military forces, including: decontamination efficacy testing; decontamination applicator and equipment testing; detector compatibility testing; CBR contamination survivability system testing; CBR material physical properties testing; and CBR contamination survivability assessments.

The concrete Decontamination Pad is 200 X 100 feet with 20-foot walls for overspray mitigation. The rebar-reinforced pad is located eight feet above grade and can handle the weight of armored vehicles. Operational since 2004, the decontamination pad is used for large-scale developmental or operational decontamination test programs, using any Dugway-permitted chemical or biological simulants.

The Decontamination Pad is used to: test the effectiveness of contamination/decontamination cycles on military equipment, systems and vehicles; training of a unit's decontamination operating procedures; and test the accuracy of chemical-biological point detector systems. The facility is permitted to use all types of decontaminants and includes a sump, pump system, and holding tank for waste disposal. The pad has multiple power ratings available and water from fire hydrants and standard hose outlets.

Decontamination Efficacy Testing

The WDTC conducts efficacy tests on developmental candidate decontaminants to determine the effectiveness of removing or neutralizing a CBR agent through its application system. Tests can also be conducted to compare the efficacy of multiple decontaminants.

Test items may include both porous (e.g., chemical agent-resistant coating paint, silicone-based) and non-porous (e.g., polycarbonates, metals, butyl rubber) materials, and can be small coupons (≈20 cm^2), large panels (one square-foot), or small military equipment.

Test officers establish a decontaminant efficacy test matrix to include test materials, agents (e.g., VX, GD, HD, *Bacillus atrophaeus*), environmental conditions (temperature and humidity), and the number of replications for each material. Coupon and large panel testing is conducted in the Combined Chemical Test Facility (CCTF) under standard fume hoods. Samples are collected using liquid samplers and an off-gassing fixture. Simulants are used for large-item efficacy testing in permitted outdoor facilities, such as the Decontamination Pad.

Contaminant droplets are applied in random patterns to the test material to achieve coverage of 10 g/m^2 for chemical agent, and 10^5 spores/m^2 of biological agent 1-5 µm in size.

Following a one-hour weathering period, the candidate decontaminant is applied to the test material, allowed to remain in contact for a specified period of time, and rinsed, if necessary. The material is vapor sampled using sorbent tubes or MINICAMS®, and liquids are sampled using silicone rubber or latex dental dam disks. Samples are analyzed with gas chromatography or liquid chromatography instrumentation to determine the level of remaining liquid or vapor residue.

Test results reported typically include:

- Contaminant application method
- Agent type and purity
- Decontamination procedures
- Decontaminant type
- Decontaminant application method
- Temperature and relative humidity
- Positive and negative control results
- Time intervals of contamination, decontamination, weathering, rinsing
- Sampling time intervals
- Biological spores recovered

Testers examine test coupons for visible signs of degradation and deterioration. Decontamination efficacy is presented as a reduction percentage of agent, spores, or particles on the coupons.

Decontamination Applicator Testing

Decontamination applicators are subjected to rigorous tests of the entire candidate system – power source, pumps, blowers, source of decontaminant, water heater, discharge hoses, wands, nozzles, and operational components – to determine the effects of decontaminants on the application system. WDTC test officers acquire reliability data during applicator operations, and provide independent verification of a manufacturer's claims of applicator capabilities.

Applicator system components are tested under a variety of environmental conditions (temperature and humidity extremes, fungal growth, salt fog) as well as dynamic testing in the physical test chamber (vibration) and the loose cargo transportation simulator (bounce table). Extensive operational tests are conducted using a variety of decontaminants; simulants may also be used during outdoor applicator system tests. Testers measure the reliability, availability, and maintainability of each component, and determine if the system meets the manufacturer specifications and warfighter requirements.

Data reported will generally include:

- Applicator system effectiveness in producing decontaminant
- Compatibility with a variety of decontaminants
- Performance parameters – discharge pressure, discharge rate, cleaning power, volume produced, coverage area
- Power usage or fuel consumption
- Flexibility of hose connections (e.g., fire hydrants, standard hose outlets)
- Performance problems – breakdowns, repair costs, leakage, safety issues

Detector Compatibility Testing

Warfighters and decontamination personnel must understand the effects of a new or fielded decontaminant on CBR detectors, primarily point detectors, and how the detector functions in the presence of a decontaminant. Detector false alarms following post-decontamination efforts may imply that military materiel or personnel have not been successfully decontaminated, thereby reducing confidence in the detector's capabilities.

The WDTC has the facilities and technical personnel to perform laboratory detector-decontaminant compatibility tests within the CCTF fume hoods, or testers may utilize the Decontamination Pad to perform compatibility tests employing a full-scale thorough decontamination line. Tests determine if a detector can be used in proximity of a decontaminant liquid or vapor without creating a false positive (i.e., detector alarms to decontaminant residues with no CBR agent present). Tests may also show if a decontaminant "masks" an agent.

Detector compatibility data provided by test officers may include:

- General trial information – trial numbers, dates, start/end times, types of test equipment used
- Pre-decontamination detector inspection and performance checks
- Test equipment pre-decontamination inspection and performance checks

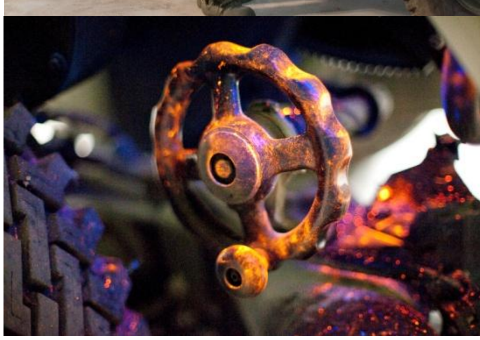
- Detector compatibility functions
- Detector post-decontamination data:
    - Detector mode settings
    - Decontaminant application
    - Decontaminant removal
    - Detection/non-detection results
    - Time intervals
    - Alarm location on test equipment

During outdoor testing, Portable Weather Information Display Systems (PWIDS) are utilized to measure and record weather conditions, which may include wind speed, wind direction, temperature, relative humidity, and atmospheric pressure.

Test officers may also make recommendations to a customer's operational procedures that can be implemented during a decontamination event to mitigate false positive detector responses.

CBR Contamination Survivability System Testing

The ability of military personnel, equipment, and systems to survive exposure in a CBR-contaminated environment and the rigors of decontamination operations is an essential component to maintaining functional capabilities during and after exposure while retaining the ability of warfighters to complete designated missions.



CBR contamination survivability test

WDTC scientists, test officers, and technicians test materials, components, equipment, and systems for CBR decontaminability, hardness, and compatibility in accordance with Army Regulation 70-75 and to meet the criteria of the Department of the Army-Approved NBC Contamination Survivability Criteria for Army Materiel.

Testing facilities include environmentally-controlled chambers designed to disseminate CBR agents. Laboratories within the CCTF and Life Sciences Test Facility (LSTF) are used for material, component and small item testing, including the **Small Item Decontamination** system. CBR simulants are used for outdoor testing of large equipment and whole systems.

The Decontamination Pad is a permitted facility that allows outdoor test and evaluation of the effects of CBR simulant contamination/decontamination (C/D) of large-scale equipment including tanks, reconnaissance and transport vehicles, unmanned systems, shelters, and support systems. Both chamber and outdoor testing are used to determine if the equipment or system meets the criteria for hardness, decontaminability, and compatibility. The WDTC also provides technical expertise to support off-site survivability test programs in cooperation with military, government, and private industry customers.

A CBR contamination survivability test may include up to five C/D cycles using representative agents or simulants. Chemical agents may include: distilled mustard (HD), thickened soman (TGD), and persistent nerve agent (VX) or a VX simulant, such as tri-n-propylphosphate (TPP). Biological simulants may include *Bacillus atrophaeus* (BG), an agent of biological origin, while a fluorescent particle (FP) simulant, such as zinc sulfide, may be used as a radiological simulant. Decontaminants may include hot soapy water (HSW), household bleach solution (5% chlorine), high-test hypochlorite (HTH) slurry, super topical bleach (STB) slurry, and other experimental decontaminants.

A C/D cycle consists of: the contamination event; a weathering period; decontamination of the material, equipment or system with agitation of the decontaminant and contaminant by brushing; a 30-minute decontaminant contact period; rinsing after the 30-minute contact period; sampling and analysis. Surfaces are inspected for visible evidence of discolor, deformities, density changes, blistering, and degradation caused by agents, decontaminants, or decontamination procedures.

Test materials, components, equipment, and systems are evaluated to determine their ability to meet decontaminability, hardness, and compatibility criteria following contamination/decontamination cycles. Performance measurements include:

- Decontaminability – Reduction of contaminant levels at or below negligible risk values, including residual chemical vapor/aerosol or liquid contact hazards; reduction of biological colony forming units (CFU) to a minimum six log reduction; minimum 2.5:1 reduction ratio of radioactive fallout simulant particles.
- Hardness – Material degradation including paint failure, hazing or yellowing of plastics, cracking or brittleness of rubber components, or corrosion of exposed metal components.

Compatibility – Degradation of crew performance in the operation of equipment/systems by personnel wearing mission-oriented protective posture, level IV (MOPP IV) gear. Testing measures the ability of equipment/system operator's ability to perform mission essential functions with and without protective equipment being worn.

For outdoor survivability testing of vehicles or whole systems, the Decontamination Pad can be prepared for CBR simulant testing, including dedicated stations – prewash, decontaminant application, decontaminant contact time, rinsing, and monitoring stage. The objective is to decontaminate the system under test (SUT) to a negligible risk (5% mild incapacitation) for personnel working inside, on, or within one meter of the item.

CBR Material Physical Properties Testing

WDTC has the capability to conduct tests on materials used in the manufacturing of military materiel. Materials tests are used to determine if contaminants and/or decontaminants have an effect on the materials. Uncontaminated coupons of materials are tested with an Instron Universal Testing Machine (with temperature extremes ranging from -70°F to 350°F) and deadweight durometer to determine their baseline performance for physical properties (tensile strength, hardness, weight, etc.).

Contaminated and decontaminated coupons can be tested and their physical properties measured and then compared to the initial properties measured. The effect of material properties changes due to contamination and decontamination cannot be extrapolated to systems effects at this time.

CBR Contamination Survivability Assessment

A Chemical, Biological, and Radiological Contamination Survivability Assessment (CBRSCA) may be conducted at Dugway or at a customer location. An assessment will determine whether the item or system is expected to meet the criteria of decontaminability, hardness, and compatibility, without subjecting the item/system to physical testing. The assessment may include both operational and non-operational modes.

Assessments are conducted by visual inspection of the item(s) and by examining technical documents, such as:

- Equipment materials lists with the aid of the Chemical Biological Material Effects database (CBME) to determine if testing on materials has been conducted and reported with data that show affects by agents and/or decontaminants, or if the materials would present a contact or vapor hazard after exposure to CBR contaminants and decontaminants.
- Materials lists and technical manuals provided by the manufacturer.
- Operation manuals
- Safety hazard analysis reports
- Production documents
- Photographs
- Test reports on similar equipment
- Completed tests, such as environmental testing and MIL-STD-810 series testing

Assessors examine components that could absorb, shield, and trap CBR agents.

The assessment includes the impact of primary or secondary contamination on the test item. Primary contamination is a result of direct, external contact with a CBR agent, or through internal contamination where areas may be exposed by open windows, doors, maintenance access points, and air ventilation ports. Secondary contamination occurs when CBR agents are transferred from a contaminated object to an uncontaminated object by physical contact, such as individuals handling or maintaining an item.

Once all data is collected, a panel of decontamination technical experts convenes to review the available data (e.g., images and system technical information, system materials, data from the CB database, and identified critical areas) and, as a group, assess the system’s ability to meet the survivability criteria. The final report includes an evaluation as to whether the item or system meets part or all of the survivability criteria, along with recommendations on decontamination treatments and vulnerability of components in the event of CBRN exposure.

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Chemical Test Division Program Support

The following is a partial list of recent programs and organizations supported by the Chemical Test Division:

Programs

- Biodome
- Canadian Collective Protection
- CBRNE Analytical and Remediation Activity (CARA)
- Chemical and Biological Defense Program (CBDP)
- Chemical-Biological Detection System (CBDS)
- Chemical/Biological Flame Resistant Glove (CBFRG)
- Chemical, Biological, and Radiological Contamination Survivability Assessments (CBRCSA)
- Decontamination Family of Systems (DFoS)
- Dismounted Reconnaissance, Sets, Kits, and Outfits (DR-SKO)
- Extended-Range Multi-Purpose Unmanned Aerial System
- Ground Soldier System (GSS)
- Ground Combat Vehicle (GCS)
- Hazard Mitigation, Materiel and Equipment Restoration Advanced Technology Demonstration (HaMMER ATD)
- Human Remains Decontamination System (HRDS)
- Individual Protection Ensemble Mannequin System (IPEMS)
- Joint Chemical Agent Detector (JCAD)
- Joint Equipment Assessment Program for Chemical and Biological Defense (JEAP)
- Joint Expeditionary Collective Protection (JECP)
- Joint Platform Interior Decontamination (JPID)
- Joint Service Aircrew Mask (JSAM)
- Joint Service Chemical Environment Survivability Mask (JSCESM)
- Joint Service Lightweight Integrated Suit Technology (JSLIST)
- Joint Service Sensitive Equipment Decontamination (JSSED)
- Large Item Decontamination
- Navy Safari Test Grid
- Next Generation Chemical Standoff Detector (NGCSD)
- Rapid Area Sensitive-site Reconnaissance (RASR)
- Stryker Nuclear, Biological, and Chemical Reconnaissance Vehicle (NBCRV)
- VX Methodology Testing

Organizations

- Army Evaluation Command (AEC)
- 20th Support Command (CBRNE)-Chemical, Biological, Radiological, Nuclear and High-Yield Explosives
- Canadian Department of National Defence
- Defense Threat Reduction Agency (DTRA)
- Deputy Under Secretary of the Army (DUSA)
- Director, Operational Test & Evaluation
- Joint Program Executive Office for Chemical and Biological Defense (JPEO-CBD)
    - JPM-Nuclear, Biological and Chemical Contamination Avoidance
    - JPM – Guardian
    - JPM - Protection
- Joint Experimentation and Analysis Division (JEAD)
- Joint Science and Technology Office (JSTO)
- Product Director – Product Director Cross Commodity Advanced Threats and Test Infrastructure (PD CCAT&TI)
- Program Executive Office, Aviation
- Rapid Integration and Acceptance Center (RIAC) Unmanned Aircraft Systems (UAS)
- Research, Development and Engineering Command (RDECOM)
- Special Programs Division
- U.S. Air Force
- U.S. Army
- U.S. Department of Defense (DoD)
- U.S. Department of Homeland Security
- U.S. Department of Justice
- U.S. Navy
- U.S. Transportation Command (USTRANSCOM)

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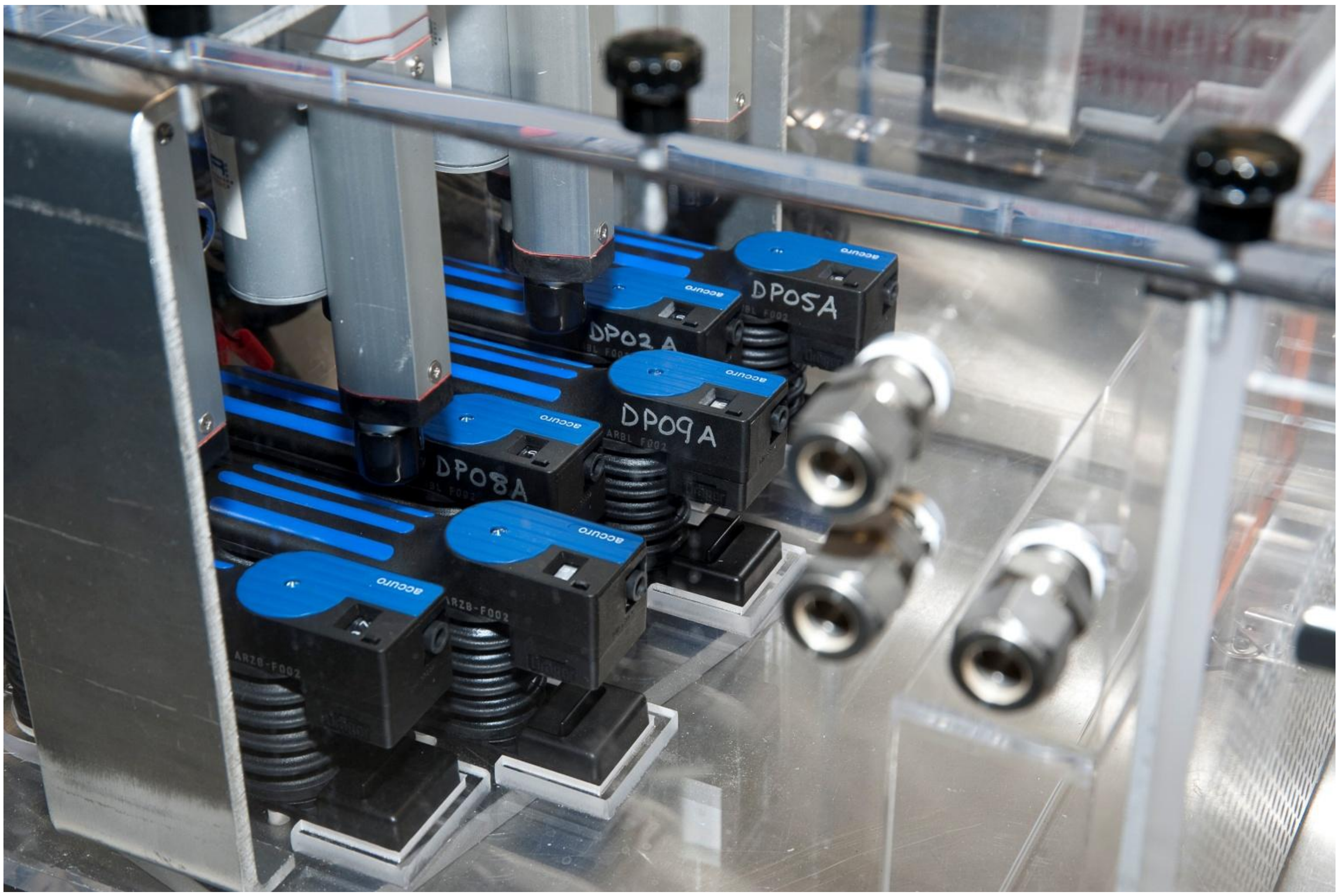
Section 5.1

Chemical Test Technologies



TOC

Advanced Air Purification Test Fixture (AAPTF)

Division: *Chemical Test*
Branch: *Chemical Test*

Capability Summary

A critical function of a collective protection (ColPro) system's environmental control unit (ECU) and filtration system is to supply breathable air to the toxic free area (TFA) of a shelter and allow military and civilian personnel to continue their missions with minimal disruption. The Advanced Air Purification Test Fixture (AAPTF), located in Building 3445, is used to test full-scale ColPro air filtration devices and air purification systems (APS) against vapor-phase chemical warfare agents (CWA).

The modular design allows the AAPTF to test single filters and APS which has included large filter breakthrough tests of M48 and M98 filters. The AAPTF accommodates vapor-phase challenges of CWAs, CWA simulants, battlefield contaminants (BFC), and toxic industrial chemicals (TIC) within an environmentally-controlled chamber.

Challenge materials within the AAPTF include vapor-phase CWAs, such as sarin (GB), sulfur mustard (HD), soman (GD), gaseous TICs, such as cyanogen chloride (CK), hydrogen cyanide (AC) and the CWA simulant, methyl salicylate (MeS).

System Description

The AAPTF is housed inside a stainless steel Chemical Agent Super Chamber (CASC) and operates as an environmental test chamber (ETC), the primary containment structure, which can maintain an average negative differential pressure of 0.5 inches of water gauge (iwg). Temperatures within the ETC may be controlled from approximately -10° to 55° C (±2° C); relative humidity (RH) may be adjusted to range from approximately 5 to 48% at temperatures above 5° C with higher RH levels maintained at low temperatures (≈5° C).

Large filter installed inside AAPTF filter housing

The AAPTF vapor dissemination system delivers vapor to dissemination ports, which are diluted with conditioned air at a fixed airflow rate, then passed through static mixers to provide a vapor challenge. Two spargers can generate continuous high-flow CWA vapor streams with temperature and airflow controls to meet target vapor concentrations. The AAPTF is capable of disseminating aerosolized challenge material by replacing a static mixing tube with a retrofitted stainless steel tube. (See AAPTF – Preview the Future for additional information.)

Chemical Agent Super Chamber

Vapor dissemination is introduced upstream of the air filtration/purification device with challenge concentration monitored upstream and downstream of the filter housing. An 8-inch duct system carries conditioned, adjustable airflow to the filter housing. Butterfly valves, baffles, and vapor mixing devices are incorporated into the ductwork to ensure that the filter will be challenged with a homogenous vapor on demand. For vapor challenges, Gasmet™ Fourier-transform infrared spectroscopy (FTIR) gas analyzers measure upstream concentrations through three sampling ports; MINICAMS® (miniature, automatic, continuous air-monitoring system) and gas chromatography (GC) instruments are used to measure downstream breakthrough concentrations. For TICs, instrumentation is selected according to the chemical composition.

The AAPTF uses a series of filter/blower units to draw air through the test fixture and dedicated filter banks for each hood to ensure contaminated air is not returned to the ETC. Conditioned and potentially contaminated air is pulled through the main filter bank located outside the ETC, cleaned, and returned to the ETC. The blower's settings can be adjusted to raise or lower the capacity of the filter/blowers, which typically runs at 60% capacity during normal operation. An air-wash option is available to ramp the filter/blowers to 100% capacity. The fixture has the capacity to generate airflow rates ranging from 60 to 2000 cubic feet per minute (cfm).

Vapor dissemination, environmental controls, and system monitoring are performed from a control room located outside the CASC. Laboratory Virtual Instrumentation Engineering Workbench (LabVIEW) software controls, monitors, and records all fixture functions, including filter/blowers, negative pressure, dissemination, referee systems, actual RH, temperatures, differential pressures, and flow rates.

The AATF has been used to:

- Test M98 and M48 filters to breakthrough using GB and GD
- Determine the scalability relationship between C2A1 and M98
- Measure real-time permeation curves for agents and their corresponding simulants

AAPTF – Preview the Future

Two new capabilities for the AAPTF will be added in 2012 to allow aerosol tests and the dissemination and monitoring of toxic industrial chemicals/toxic industrial materials (TIC/TIM).

A removable aerosol generator with balance and differential pressure (DP) instrumentation will disseminate liquid and dry aerosol sprays. A Malvern® Spraytec™ particle size measurement system will provide accurate detection of up-stream particle size distribution.

The fixture will be upgraded to accommodate gas cylinders for TIC/TIM (e.g., chlorine and sulfur dioxide) dissemination system, detection instrumentation to monitor high- challenge concentrations and low-level breakthrough concentrations, and additional safety air monitoring systems.

System modifications will allow the testing of advanced air-purification devices, such as catalytic oxidation (CatOx) systems, passive filtration panels, and regenerative (REGEN) filters.

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Chemical Cloud Tracking System

Division: *Test Engineering and Integration* **Branch:** *Test Data imaging*

Capability Summary

Dugway's chemical cloud tracking system (CCTS), titled 3D-Tomography for Realization of Actual Chemical Kinetics (3D-TRACK), is a networked system of passive standoff infrared detectors that track chemical vapor cloud movement over large areas and produce concentration maps in real time. The CCTS is used as a referee system during testing and evaluation of fielded and next-generation point and standoff detectors.

The system monitors the movement of chemical clouds beginning at the release point and across the test grid for an average of 10-15 minutes. The CCTS is capable of tracking clouds up to four kilometers away.

The CCTS merges data from its multiple scanning Fourier-Transform Infrared Spectrometer (FTIR) sensors which mathematically reconstructs a three-dimensional concentration map from the individual sensor information. The system relies on wireless data transfers from each sensor to the field command post where the concentration maps are generated and displayed.

FTIR sensor at Tower Grid

System Description

Four- to five FTIR sensors are typically placed 1-2 km from grid center and scan over pre-defined search and background patterns. Data transmitted from each sensor to the command post generates a new 3-D concentration map about every 15-20 seconds.

Each FTIR sensor measures the concentration pathlength value of the cloud within its field of view in real time and relays this information back to the map/display computer at the command post. Cloud map data can be exported and graphed in both two dimensions and three dimensions.

FTIR sensors feature built-in global positioning system (GPS) units and digital compasses, so the location and pointing direction of all sensors is automatically obtained. The command post computer displays the cloud map as an overlay on a United States map and every 15-20 seconds a new cloud replaces the previous cloud on the map. Operators in the command post can zoom in on the exact location of the cloud.

The CCTS features eight units capable of tracking clouds of CB simulants and TICs, including: sulfur hexafluoride (SF_6), triethyl phosphate (TEP), acetic acid, methyl salicylate (MeS), and ammonia.

The CCTS has supported multiple test programs sponsored by: the Joint Project manager for Nuclear, Biological, Chemical Contamination Avoidance (JPM NBCCA) (Sunblock, NGCSD); Department of Homeland Security and TSA (Jack Rabbit); and National Ground Intelligence Center (Wild Stallions).

TOC

Chlorine Detection Systems

Division: *Test Engineering & Integration* **Branch:** *Test Data Imaging*

Capability Summary

The increasing threat of chlorine as a terrorist weapon (or possible accidental release) has given rise to increased testing with chlorine gas, as well as other toxic industrial chemicals and toxic industrial materials (TIC/TIM), in chambers and on the test grid at Dugway Proving Ground (DPG). Scientists and test officers deploy the Cerex UV (Ultraviolet) Sentry and Cerex UV Canary for real-time detection of chlorine gas levels.

The UV Sentry and UV Canary have supported small-scale chamber test programs for the Joint Chemical Agent Detector (JCAD) and Next Generation Chemical Standoff Detection (NGCSD) system. The UV Sentry and UV Canary have functioned as referee detectors for multiple outdoor trials that involved releases of large quantities of chlorine gas to provide the Department of Homeland Security (DHS) and Transportation Security Administration (TSA) a better understanding of large-scale chemical releases. Data collected from the DHS/TSA tests are intended for enhanced modeling methodologies, refinement of emergency response procedures, and development of more effective hazard mitigation strategies.

System Description

The UV Sentry and the UV Canary feature control computers with a 2 GHz CPU, 1 GB of RAM, and a 32 GB solid state hard drive. System clocks and all recorded data are GPS time synchronized through an onboard GPS unit. The systems include continuous monitoring software for data collection, analysis, and charting.

UV Sentry open-path spectrometer

UV Sentry

The UV Sentry is a two-part, open-path spectrometer that uses ultraviolet light to detect and analyze airborne chlorine gas. A standoff detector, the UV Sentry is used in field trials to provide real-time chlorine analysis up to 1000 meters while detecting path-integrated concentrations from 3 to 10,000 ppm.

A xenon arc lamp serves as the source and a receiver uses collection optics to focus the ultraviolet light to a fiber optic which is sent to the spectrometer. The UV Sentry features a sealed calibration cell, spectral library, Microsoft Windows® OPS, USB, Ethernet and wireless interface, and remote communications radio modem. Data from the UV Sentry is transmitted back to a command post through wireless radio signals allowing for real-time viewing of stimulant concentrations and system status and control.

The UV Sentry units have been upgraded to include a GPS to increase safari capabilities and inter-range instrumentation group (IRIG) time code synchronization hardware with associated software modifications.

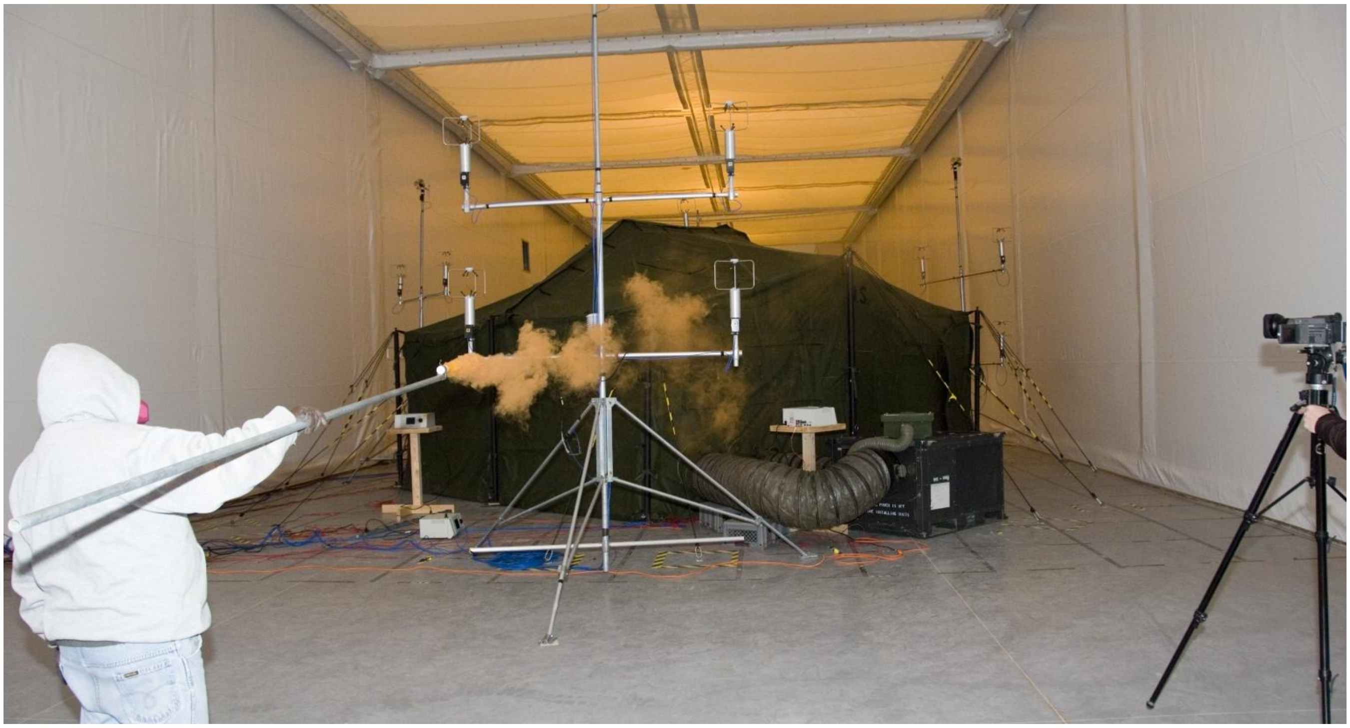
UV Canary system set up for real-time chlorine gas detection

UV Canary

The UV Canary provides real-time detection of chlorine gas levels from 10 to 10,000 ppm and is designed to operate under extreme desert temperatures (0° to 40°C) and varying environmental conditions.

The UV Canary samples air through a Teflon® tube into a gas cell where a light-emitting diode (LED) source measures chlorine concentration by ultraviolet absorption. The system compensates for errors resulting from source intensity variances, ambient air fluctuations, and optical obstruction by taking differential measurements by splitting the source output into two beams. One beam passes through the gas sample cell while the other beam passes through an empty reference cell.

Concentrations are calculated by comparing measurement values to calibrated gas-specific library spectra with temperature and pressure compensation. Real-time data is recorded on the hard drive.



Collective Protection Airflow Mapping

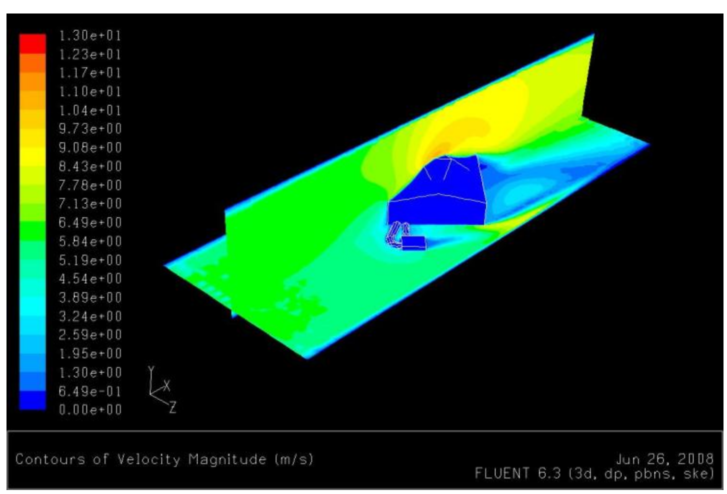
Division: *Chemical Test* **Branch:** *Chemical Test*

Capability Summary

The West Desert Test Center's (WDTC) ability to test a collective protection (ColPro) system's capacity to withstand a chemical or biological (CB) attack is enhanced by the capability to measure, map, and model airflow that carries agent toward, around, and away from a system. Airflow mapping of ColPro systems enhance test and evaluation tools which leads to fielding more effective protection for U.S. and allied warfighters.

Scientists, engineers, and test officers have developed methodologies and test programs to predict optimal performance and improve military leaders' understanding of airflow impact on new or fielded ColPro systems. In addition, airflow mapping can reduce the time of full-system field testing by clarifying the amount of protection afforded by the ColPro structure.

Verified airflow models demonstrate how a ColPro system can: offer more effective protection at a particular orientation; show how entry/exit could be restricted during an attack when wind is blowing from a particular direction and at a certain speed; and improve the ability to design future systems.



Test officers can implement airflow mapping tests, applying multiple wind angles, for ColPro systems up to 28 feet in length; ColPro systems up to 100 feet may be mapped with air flows directly up-wind or down-wind.

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Airflow Mapping

ColPro systems under test (SUT) can be characterized to predict optimal performance through trials performed in the **Joint Ambient Breeze Tunnel (JABT)**, providing new ColPro acquisition programs a resource for testing and model development. The JABT is characterized for CB simulant challenges using aerosol and vapor disseminations.

Airflow and aerosol concentrations around a SUT can be mapped as a function of tent position, time, and airflow through the JABT using computational fluid dynamics software. The JABT ceiling can be raised or lowered to accommodate desired air flow speed and fan pitch adjusted to achieve specific tunnel airflow.

Airflow mapping inside the Joint Ambient Breeze Tunnel

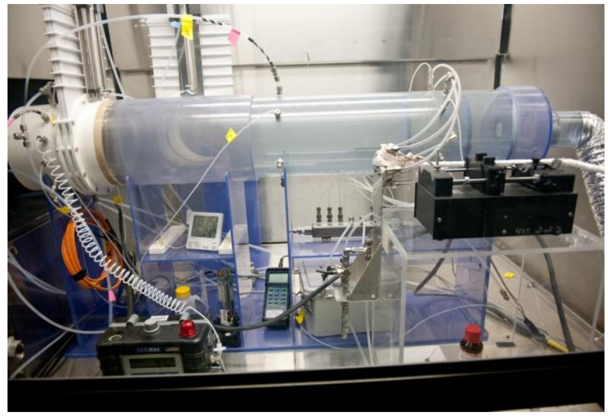
Airflow is measured using portable weather information and display systems (PWIDS) and by sonic anemometers or three-dimensional ultrasonic anemometers. Additional instrumentation measures horizontal wind components, temperature, humidity, and barometric pressure.

Aerosol concentrations are disseminated, sampled, and measured with particle monitoring instrumentation as a function of size (aerodynamic diameter range from 1- to 10 µm) or by total density. All instrumentation is time-synchronized using a global positioning system (GPS) time generator. Instrumentation for data collection may be placed in a variety of configurations and repositioned for each mapping trial in conjunction with the placement of the ColPro system.

An airflow methodology investigation at the WDTC involved subjecting a fielded Modular General Purpose Tent System (MGPTS), positioned at various orientations to 50 steady-state airflow velocity components and 27 steady-state aerosol concentration trials; flow patterns were confirmed by detailed measurements and five trials using smoke. During each type of trial, tunnel airflow, temperature, barometric pressure, and relative humidity were measured.

Immersion Chamber

Division: *Chemical Test* **Branch:** *Test Execution*


Immersion Chamber

Capability Summary

The West Desert Test Center (WDTC) developed a unique and versatile immersion chamber to test and evaluate multiple point detection systems in a controlled environment using chemical warfare agent simulants. Testers can evaluate detection performance of detector systems by challenging them side-by-side with a broad range of chemical vapor concentrations and interferents, and initiating on-demand challenges. Testers can determine time response of the detectors based on time-to-alarm and time-to-clear information.

The chamber can disseminate a large volume (≥200 L/min.) of homogenous chemical simulants, including methyl salicylate (MeS), triethyl phosphate (TEP), acetic acid (AA), tripropyl phosphate (TPP), and diethyl malonate (DEM), plus a mixture with battlefield contaminants, such as diesel exhaust.

The chamber provides fast vapor concentration up-and-down ramping between 0.1 and 30 mg/m^3 within a 15-minute period. A steady-state challenge of a SUT may be as short as one minute, or can extend for three days at low concentration (.001 mg/m^3).

System Description

The immersion chamber was designed and constructed at the WDTC to generate a constant stream of targeted simulant vapor concentrations and to challenge detectors under ambient conditions. The chamber's modular construction, approximately 62 inches long with a 7.8-inch inner diameter, features a vapor dissemination system, a mixing and delivery system, the SUT chamber, and a venting port.

Vapor dissemination systems can adapt to various types of simulant vapor generators--diffusion tube generators, double dilution systems, syringe pumps--depending on the test requirements. Vapor is disseminated into the mixing and delivery system via multiple vapor dissemination points, and then directed to either the SUT chamber or the venting port using switch gate valves, enabling on-demand challenges.

Quick Facts

Immersion Chamber CWA Simulant Vapor Dissemination & Challenging Capability

CWA Simulant	Vapor Concentrations	Continuous Vapor Challenge Time Duration Tested
TEP	.01 to .0008 mg/m^3	3 days
TPP	.0002 mg/m^3	30 hours
MeS	10 to .00005 mg/m^3	30 min.
AA	4.5 mg/m^3	10 min.
DEM	30 to 0.1 mg/m^3	3.5 hours

The test chamber interfaces with vapor referee systems providing vapor concentration profiles within the SUT chamber and delivery systems. MINICAMS® and GC/MS instrumentation integrated with a continuous preconcentration system provide near real-time (NRT) monitoring. Gasmet™ analyzers are used for real-time monitoring.

The size of the SUT chamber can be adjusted to accommodate entire hand-held point detection systems. Sampling ports mounted on a bracket can be installed to challenge large point detection systems.

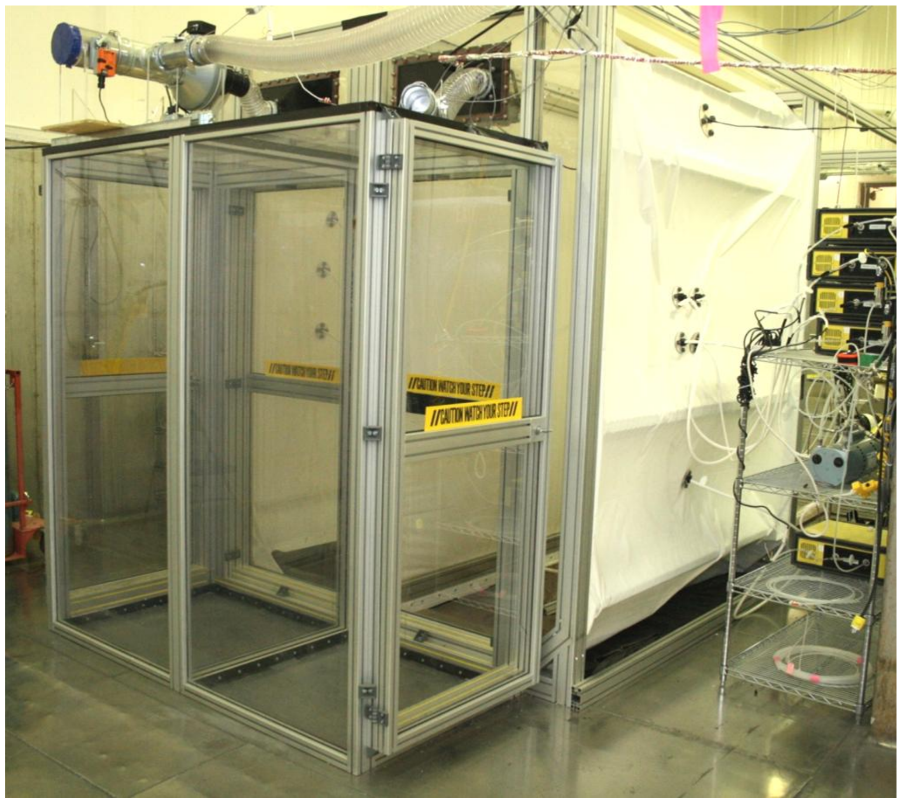
Novel Closures Test Fixture (NCTF)

Division: *Chemical Test* **Branch:** *Chemical Test*

Capability Summary

Military personnel who utilize collective protection (ColPro) shelter systems must trust that closures, seams, and pass-through ports adequately impede or severely restrict migration of chemical agent vapors from a contaminated atmosphere into the shelter.

The Novel Closures Test Fixture (NCTF) is designed to evaluate the performance of new closure systems (e.g., zippers, hook-and-pile, zip-track designs) and seam technologies in their ability to prevent penetration or permeation of chemicals into the clean area of a ColPro shelter. Test officers use chemical agent simulants to evaluate the protective capability of the candidate closure in a controlled environment and prior to field testing.



Airlocks attached to Novel Closures Test Fixture

Test personnel subject the closure/seam to vapor challenges (sustained and pulse) covering a 12-hour or 48-hour period, with test conditions performed under positive, negative, or equalized pressure between fixture compartments. Simulants disseminated within the NCTF have included methyl salicylate (MeS), trimethyl phosphate (TMP), and triethyl phosphate (TEP). The test dissemination compartment is maintained at a negative differential pressure of -0.15 iwg to prevent simulant leakage into the surrounding chamber environment.

System Description

The NCTF is a rectangular, rigid-aluminum frame, open on the top and bottom, with an aluminum support frame positioned in the center of the structure adding support to the top and bottom. The fixture frame allows for the length of the fixture to be adjusted to accommodate various sizes of closures.

Two airlocks are attached at one end, secured with an acrylic plastic wall (another acrylic wall is attached to the opposite end to enhance rigidity), which provides access to the toxic free area (TFA) compartment and to the dissemination compartment. Airlock doors allow test personnel to enter and exit the fixture without compromising test compartment air pressures.

Novel closure embedded in barrier wall

Vapor-tight polyethylene liners, capable of maintaining differential atmospheric pressures, are installed lengthwise on each side of the test fixture creating two fully-enclosed compartments separated by a barrier wall in which the test closure is embedded. Liners and the barrier wall are comprised of materials/fabric typically used in a fielded ColPro shelter. The barrier wall is mounted and sealed to the test fixture with the only opening being the embedded novel closure or seam to be tested and evaluated. The length of the test fixture is limited to a minimum of six feet and a maximum length of 14 feet.

Sealed pass-through panels from the exterior of the fixture through the liners provide service for ductwork, air lines, electrical lines, detectors, sampling lines, and other instrumentation or hardware. Multiple sealable ports within the dissemination and the TFA compartments allow for uniform vapor challenge, measurement and recording of environmental conditions, sampling lines, analytical equipment, and instrumentation.

Blower motors provide liner inflation and sustain required air pressure differentials; effluent from both compartments is exhausted directly into the chamber air filtration system. Differential pressure monitors are located inside and outside the fixture and pressure from all locations is measured, recorded, and monitored.

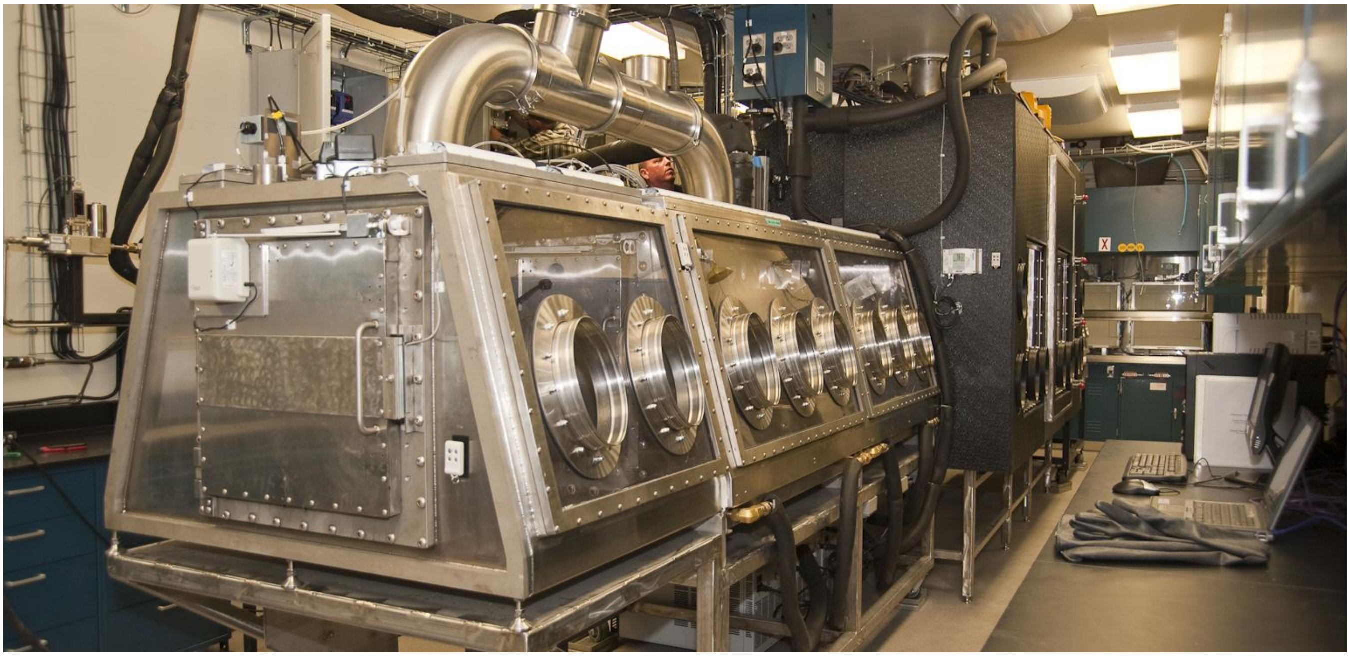
Analytical instrumentation provides near real-time (NRT) response and analysis, combining MINICAMS®, FTIR gas analyzers, point detectors, and cumulative sampling devices in both the TFA and dissemination compartment to accurately evaluate the chemical resistance of the closure or seam.

Potential future upgrades to the NCTF would allow for challenging closures and seams with chemical warfare agents (CWA) and toxic industrial chemicals (TIC) under environmentally-controlled (temperature and relative humidity) conditions.

Quick Facts

- Test fixture dimensions:
  - ≈8 ft. (≈2.5 m) wide
  - ≈9 ft. (≈3.0 m) high
  - ≈6 ft. to ≈14 ft (≈2.0 m to ≈4.3 m) variable length
- Dissemination compartment instruments detection: 1 to 5,000 mg/m³
- TFA instruments detection: 0.001 to 10 mg/m³
- Pressure range in each compartment: -0.25 to +0.75 iwg (±0.10 iwg)

TOC



Small Item Decontamination (SID) System

Division: *Chemical Test* **Branch:** *Chemical Test*

Capability Summary

The U.S. military continues to develop and rely upon cutting-edge technology to improve the survivability of warfighters stationed around the world. However, if highly-sensitive equipment becomes exposed to chemical, biological, or radiological (CBR) contaminants, or, toxic industrial chemicals/toxic industrial materials (TIC/TIM), it must be able to withstand a thorough decontamination process and remain functional to sustain military operations.

The Small Item Decontamination (SID) system is designed to subject fielded and developmental materials, components, and sensitive equipment to rigorous contamination/decontamination (C/D) cycles, under environmentally controlled conditions. SID allows test officers to evaluate the survivability of the test items as well as to determine the efficacy of fielded and developmental decontaminants and decontamination delivery systems (e.g., decontamination kits, portable decontamination devices).

Small items may include sensitive equipment, components, coupons (e.g., glass, plastic, or metal materials), small arms and ammunition, and personal gear. Sensitive equipment may include: radios, laptop computers, night vision goggles, point detectors, satellite phones, range finders, sights, and cockpit subcomponents. Test officers perform a pre-decontamination baseline function on sensitive equipment to determine the impact of system decontamination; functional tests are performed after each completed decontamination cycle, and again after 30 days.

System Description

SID is an environmentally-controlled system that features a series of four, integrated, stainless steel and Plexiglas® modules with sealed glove portals, whereby test items pass through stages of contamination, decontamination, and contact or off-gas sampling. The SID module is designed to maintain temperatures ranging from approximately 60° to 138°F and relative humidity from 10% to 90%.

SID glove ports

The first module is a two-foot airlock whereby test items and contaminant applicators are staged without compromising the environmental settings in the contamination/weathering module. Test items are moved from the airlock to the contamination module where they may be challenged with chemical agents (e.g., VX, GD, HD), TIC/TIMs, agents of biological origin (ABO), or simulated radioactive fallout particles or fallout from a radiological dispersal device. Once contamination application is complete, test items are moved to the weathering area (except for biological samples), to undergo a one-hour weathering period.

The decontamination process occurs within the Decontamination Chamber, a ≈285 cu. ft. fixture designed to maintain temperatures ranging from -20° to 140°F and relative humidity from 10% to 90%. Decontaminants may include vaporized hydrogen peroxide (VHP), super topical bleach (STB), high-test bleach (HTH), hot soapy water (HSW), hot air, hot moist air, foams, and sorbent powders.

SID test monitoring station

After a decontamination cycle is complete, test items are transported to either the contact sampling module or to the vapor off-gas boxes located in adjacent fume hoods. Test items are contact sampled for residual agent using latex rubber contact samplers and then analyzed.

Coupons can also be solvent extracted to determine residual liquid in the material.

Quick Facts

Current and future test programs scheduled to be supported by SID include:

- Joint Platform Interior Decontamination (JPID)
- Decontamination Family of Systems (DEoS)
- Chemical Biological Radiological Containment Survivability (CBRCS) Tests
- Intelligent Munitions System (IMS) CBRN Tests

Test items designated for vapor sampling are placed into stainless steel, off-gas cells, sampled with solid sorbent tubes (SST) and analyzed with gas chromatographs (GC), or sampled with miniature, automatic, continuous air monitoring systems (MINICAMS®). MINICAMS® detection limits are: HD to 0.0004 mg/m^3, GD to 0.00005 mg/m^3, and VX to 0.000001 mg/m^3. GC detection levels for challenge chemical agents are down to 0.5 µg/mL.

The analysis of biological samples in colony-forming units (CFU) is performed by microbiologists in the Life Sciences Test Facility. A successful ABO test results in at least six-log reduction of CFU.

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Simulant Agent Resistant Test Manikin (SMARTMAN)

Division: *Chemical Test* **Branch:** *Chemical Test*

Capability Summary

The Simulant Agent Resistant Test Manikin (SMARTMAN) system, located within the Combined Chemical Test Facility (CCTF), has long been the central fixture to test the ability of individual protective (IP) breathing equipment to resist permeation following exposure to chemical warfare agents (CWA), such as distilled mustard (HD) and sarin (GB). More recently, scientists and test officers have validated SMARTMAN headforms and chambers as controlled environments to measure challenge and breakthrough of low levels of persistent nerve agent (VX) on protective masks.

For more than 10 years, SMARTMAN's artificial respiratory capabilities have been used to evaluate a variety of IP breathing equipment, including the Joint Service Aircrew Mask (JSAM) Military Protection Unit (MPU-5) and Apache JSAM Mask (MPU-6), the Joint Services General Purpose Mask (JSGPM) mask (XM-50), and Joint Service Chemical Environment Survivability Mask (M52). In addition, SMARTMAN has been used to successfully test air-purifying respirators (APRs), powered air-supplying respirators (PAPRs), and Chemical Biological Radiological Nuclear (CBRN) escape mask systems.

The SMARTMAN system features four ergonomically designed, cast zinc headforms, including neck, shoulders, and upper chest, which are coated with sealant. SMARTMAN operates inside chambers with temperature and relative humidity (RH) controls to evaluate an existing or prototype breathing device's resistance to CWAs. Individual masks/respirators and protective ensembles, including hoods, helmets, or other headgear, are tested and evaluated with the SMARTMAN system. The chambers have also been used to test protective gloves and boots, and real-time chemical agent detectors.

SMARTMAN in protective ensemble

System Description

The SMARTMAN headforms and chambers provide a controlled environment to measure vapor challenge concentrations and breakthrough of respiratory protection prior to field testing the equipment. Sampling and measuring ports are located in a headform's nostrils, left eye, and forehead of a semi-detachable face. Instrumentation attached to the eye port collects vapor samples that penetrate into the upper area of the breathing device. Left nostril instruments measure vapor that penetrates into the orinasal portion of the device; right nostril instruments record pressure differential between inside the mask and the chamber. The forehead port may be used for sampling or pressure measurements.

The mouth port is used for simulated respiration and is connected by tubing to a ventilator/mechanical lung or to a motorized syringe pump. The ventilator allows adjustment of tidal volume from .05 to 3.0 L (2 to 40 breaths per min), and has alarms for high and low pressure, and for breathing rate parameters that exceed airflow rates. Air from the ventilator is pumped into a mechanical lung system which is equipped with springs to simulate the compliance of lungs, as well as pressure gauges and a tidal volume indicator. The motorized syringe can deliver tidal volumes of 0.5, 0.75, 1.0, 1.5, and 2.0 L at respiratory rates ranging from 6 to 59 strokes per minute.

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An inflatable butyl rubber seal between the face and headform creates a leak-tight interface between the breathing device peripheral face-seal and the headform. If a device does not have a face-seal, such as an escape mask that uses a neck dam, the seal prevents chemical vapors from leaking into the interior of the mask.

The SMARTMAN headform is mounted inside a 0.23 m^3 stainless steel chamber which regulates airflow (0 – 100 L/min.), temperature (0^o to 50^oC), and relative humidity (20% to 80%). Conditioned, analyte-laden air enters the chamber through an airflow manifold which is mixed with unconditioned air and circulated by fans to provide consistent airflow throughout the chamber.

Masks/ensembles are typically tested in a prototype, new, or used state, as well as having been pre-conditioned with battlefield contaminants, such as hydraulic fluid, diesel fuel, insect repellant, jet propulsion fuel (JP-8), and reactive skin decontamination lotion. Masks/ensembles are also tested after having been stored under various environmental conditions which simulate arid, tropical, and arctic climates. Finally, masks/ensembles are tested after being subject to extreme environmental conditions simulating a battlefield, such as temperature shock, rain, dust, sand, and salt fog.

Each mask/ensemble 24-hour trial consists of vapor agent challenges (GB: 100 – 4000mg/m^3), liquid/vapor challenges (HD: 5 – 50mg/m^3 and liquid drops) or liquid-only (VX: 10-µl drops at a contamination density of 10 g/m^2). Vapor challenges are disseminated by a syringe pump through a Dugway custom-built disseminator head that features air intake and outlet ports, a septum mount, and heater cartridge mount. Conditioned air flows from the temperature, flow, and humidity controller into the air inlet port and across a plate heated by a 500-watt cartridge heater.

Testers use MINICAMS® (miniature, automatic, continuous air-monitoring system) to measure real-time chemical agent permeation through the mask or ensemble, and Miniature Infrared Analyzers (MIRAN), and Airwave Electronics Ltd. sulfur or phosphorus analyzers to monitor challenge concentrations.

Example test objectives for masks may include a cumulative breakthrough concentration multiplied by time (CT) of less than 1 mg-min/m^3 for GB and less than 25 mg-min/m^3 for HD, over 16 hours and over 24 hours; and for VX, less than 0.012 mg-min/m^3 over 16 hours or 0.018 mg-min/m^3 for 24 hours.

Upon completion of a test, a data package delivered to a customer may include:

- Calibration curves for the challenge and breakthrough
- Cumulative dosages
- Graphs or charts of concentration readings behind mask sample points'
- Chamber challenge concentration as a function of time
- Temperature and humidity
- Pressure differential between chamber and test item
- Flow rates
- Case narrative

Swatch Including Filter Test (SWIFT) System

Division: *Chemical Test* **Branch**: *Chemical Test*

Capability Summary

^{d}FIX with small air filters

The near real-time (NRT) Swatch Including Filter Test (SWIFT) system is designed for individual protection equipment (IPE) and collective protection equipment (ColPro) vapor or liquid swatch permeation tests, swatch and coupon off-gassing, filtration fabric permeation, and small-scale filter permeation tests. SWIFT operations encompass multiple dissemination configurations, NRT detection systems, sample collection, environmental controls, and instrumentation systems.

The Dugway Fixture (^{d}FIX) is a central component of SWIFT designed to house multiple test materials that are subject to a wide variety of environmental conditions and to challenge test materials with a range of chemical agent or simulant threat challenge concentrations. Challenge materials may include sarin (GB), soman (GD), distilled mustard (HD), and persistent nerve agent (VX), or simulants such as trimethyl phosphate (TMP), triethyl phosphate (TEP), and tripropyl phosphate (TPP).

IPE and ColPro swatch permeation test materials have included standard nitrile, black nitrile rubber with a nylon insert, Joint Service Lightweight Integrated Suit Technology (JSLIST) materials, Army combat uniform (ACU) fabrics, butyl rubber, barrier and liner materials, and filtration materials up to a quarter-inch thick. Offgassing test materials have consisted of building materials (e.g., wood, concrete, latex paint, stainless steel, and polyvinyl chloride), JSLIST and ACU materials, butyl rubber, TEMPER (tent, extendable, modular, personnel) materials, and liner and single skin and gasket materials. Test materials may be pre-treated with battlefield contaminants (BFC), such as wasp spray, bleach, jet propulsion fuel type 8 (JP-8), and JP-8 exhaust.

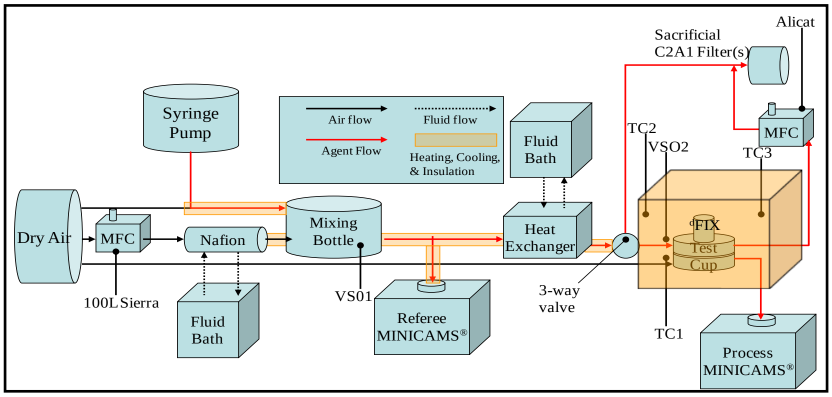
Capability Description

West Desert Test Center (WDTC) scientists and test officers utilize SWIFT to determine the degree and time of agent/simulant permeation through various test materials. SWIFT produces data on the effects of wear, battlefield contaminants, and environmental conditions on the rate of agent permeation through test materials and also establishes agent-to-simulant relationships required in system-level testing. SWIFT collects informational points at frequent intervals allowing investigators to calculate both a permeation curve and permeation coefficient for each test item.

Swatch cells inside ^{d}FIX

SWIFT is compatible with a range of dissemination and instrumentation systems with specific configurations and associated methodologies to provide test conditions for liquid and vapor permeation and off-gassing of pliable and rigid materials and small filters.

Test materials are housed within a ^{d}FIX enclosure designed and built at Dugway Proving Ground (DPG). The ^{d}FIX has supported multiple Joint Expeditionary Collective Protection (JECP) test programs, including passive and active air filtration system tests, Simulants for Protective Equipment Testing (SPET), and performance specification testing (PST) of barrier swatches.



SWIFT test apparatus schematic used for agent/simulant permeation trials

The ^{d}FIX enclosure is constructed of insulated acrylic panels and fits inside of a standard chemical fume hood and allows multiple test items to be challenged with agents or simulants. A thermoelectric heating/cooling unit provides the ^{d}FIX with controlled temperatures ranging from approximately 5° to 55°C with a gradient of ±5°C. Operational relative humidity (RH) can be generated and controlled through the challenge airflow to range from approximately 0 to 85% (±5%), depending upon temperature. The front wall of a ^{d}FIX is removable while sliding doors on each side open to allow the passage of test items; small entry ports open at the bottom for tubing and wiring. A shelf may be inserted into the ^{d}FIX to accommodate 3 to 6 test items, or the ^{d}FIX can be operated without the shelf to test larger items.

Dissemination components of SWIFT include an airstream (generated from in-house compressed air or compressed gas cylinders), agent or simulant vapor generation, and humidity generation system. Agent/simulant disseminators include a syringe pump, for challenges with low flow rates (≈2 L/min), and sparger-type disseminator for high flow rates. The mixed and conditioned airstream flows to the ^{d}FIX. Challenge vapor concentrations have ranged from 1 mg/m³ for VX up to 5000 mg/m³ for GB, depending on vapor pressure of challenge compound, challenge temperature, and humidity.

A variety of instrumentation is used to collect and quantify test agent or simulant vapor, both in real time or NRT; vapor may also be collected in sampling devices, such as solid sorbent tubes, for post-test analysis. MINICAMS® (miniature, automatic continuous air monitoring system) or Gasmet™ Fourier transform infrared spectroscopy (FTIR) gas analyzers record challenge vapor concentrations prior to contact with the test items. MINICAMS® record permeation breakthrough in swatch tests, and MINICAMS® fitted with a flame photometric detector (FPD) and flame ionizing detector (FID) provide continuous monitoring for offgassing tests.

Quick Facts

Dugway scientists have conducted over 400 trials using SWIFT generating ≈1,200 diffusion/ permeation curves from which diffusion/permeation coefficients have been calculated.

Laboratory Virtual Instrumentation Engineering Workbench (LabVIEW™) software and control hardware is used for instrument and environmental control and data acquisition during tests. Test data collected and reported may include: trial duration, agent control numbers and purity, simulant lot numbers and purity, BFC applied, temperature before, during, and after each trial, RH, vapor challenge concentration x time (Ct), permeation concentration in mg/m³, volume of liquid dispensed onto a swatch in µL, and permeation breakthrough times and curves.

SWIFT has successfully characterized protective materials and equipment using known detectors and can be used to characterize novel detectors within known environmental parameters.

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Section 5.2

Chemical Analyses

Laboratory Instrumentation

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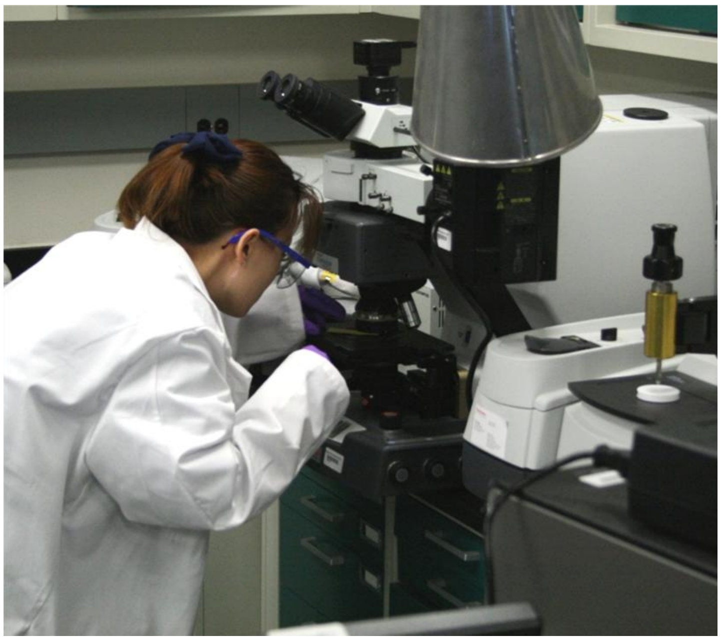
Chemical Analyses and Laboratory Instrumentation

For nearly 70 years, one of the primary missions at Dugway Proving Ground has been to support the U.S. military through testing defense systems and equipment protection against the effects of chemical warfare agents (CWA), which originally included blood, blister, choking, and nerve agents.

More recently, the threat has intensified to include toxic industrial chemicals and toxic industrial materials (TIC/TIM), and other emerging threat chemicals, accelerating the need for scientific understanding of chemical and physical properties, toxicology, and the impact upon warfighters, civilians, and the environment.



Sample analysis using a Nicolet™ Continuµm™ microscope interfaced with a Nicolet™ 6700 FTIR spectrometer

The West Desert Test Center (WTDC) combines the analytical expertise of its technical staff with over 50 state-of-the-art instruments to separate, identify, and quantify the chemical components of natural and artificial materials.

Chemical Analyses

Scientists at the Combined Chemical Test Facility (CCTF) continuously develop test-specific methodologies for CWAs, CWA simulants, TIC/TIMs, and emerging threat chemicals, and analyze the feasibility of proposed methodologies, which can be used for non-systematic tests that require new testing approaches. The CCTF is equipped with state-of-the-art instrumentation to support chemical warfare defense programs, including individual and collective protection, contamination avoidance, and decontamination programs.

Existing analytical instrumentation, including liquid chromatography/mass spectrometry (LC/MS), gas chromatography/mass spectrometry (GC/MS), MINICAMS® (miniature, automatic, continuous air-monitoring system), and nuclear magnetic resonance (NMR) spectroscopy, support the following chemical analyses: quantitative and qualitative analysis of CWA, TIC/TIMs, and simulants; validation of Army Research, Development, Test and Evaluation (RDTE) diluted solutions; purification analysis; witness card and filter paper analysis; biotoxin analysis; and safety air monitoring.

Future capabilities will include the development of methodologies for quantitative measurements and structural identification of unknown compounds. Additional instrumentation capabilities will include elemental mass spectrometry, vibration spectroscopy, and advanced nuclear magnetic resonance (NMR) spectroscopy to be used for:

- CWA analysis using GC/MS, LC/MS, inductively coupled plasma mass spectrometry (ICP-MS), and electrophoretic separation techniques
- Non-contact TIC and chemical analysis using molecular vibrational spectroscopy
- New methodology development to support non-traditional test programs

Laboratory Instrumentation

CCTF scientists, chemists, and technicians perform chemical analysis, synthesis, trace analysis, chemical neutralization studies, and methodology development, with state-of-the-art instrumentation. The following is a synopsis of instrumentation supporting Dugway's mission.

Chromatographic and Electrophoretic Instrumentation

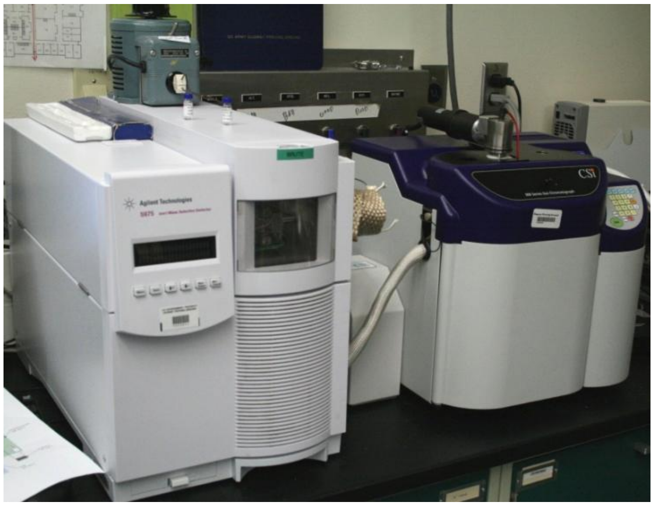
Gas chromatography (GC) is used in analytical chemistry for separating and analyzing compounds that can be vaporized without decomposition. GC is typically used to test the purity of a substance or to separate the components of a mixture. Liquid chromatography (LC) is used to separate, identify, and quantify compounds based on their idiosyncratic polarities and interactions with the LC instrument's column stationary phase. Electrophoresis is the motion of dispersed particles relative to a fluid under the influence of a spatially uniform electric field. Electrophoretic instruments produce strong electric fields to separate molecules based on differences in charge, size, and hydrophobicity.

Sample loading and preparation for automated GC analysis

Gas Chromatography (GC) – The CCTF features 14 GC units with 100-position autosampler trays that support quantification analysis for: RDTE solution and standard solution preparations; bubbler analysis for swatch testing; solid sorbent tube (SST) analysis for safety air monitoring; and agent stability studies. Current available methodologies include RDTE diluted solution analysis, blister agent analysis for sulfur mustard (HD), and nerve agent analysis (GB, GD, GA, and VX @>0.05 µg/mL). GCs coupled with flame photometric detectors (FPD) or flame ionization detector (FID) can quantify samples ranging from 0.5 to >1000 µg/mL.

Liquid Chromatography (LC) – The five LC systems are used for methodology development and chemical agent identification and quantification. System features include: 108-vial autosampler with an injection volume of 0.01 to 2000 µL, degasser, temperature-controlled column compartment (10^o below ambient temperature to 80^oC), diode array detector, and fluorescence detector. A binary pump draws solvent into tubing, generating pressure within the system. The two-component mixture ("mobile phase") flows (0.050 to 5 mL/min.) through the autosampler tubing where a sample is injected. Mobile phase, sample matrix, and column stationary phase interact to yield separation. Separated compounds are detected either by a diode array detector (DAD) or fluorescence detection (FLD) system.

- DAD is a multi-wavelength detection system (5 units), that enables the simultaneous collection of absorption data (80 Hz data acquisition rate) from a range of ultraviolet and visible wavelengths (UV/Vis). Organic compounds have characteristic UV/Vis absorption spectra due to the presence of chromophoric groups or structures which are identified as samples and pass through the detector. The LC-DAD simultaneously monitors a range of wavelengths (190 to 950 nm) within the absorption spectrum of a compound that can be produced and compared with standard spectra from reference compounds. Analysis times range from 0.2 to 20.0 min., cycle times range from 0.5 to 2.5 min., and gradient times range from 0.2 to1.5 min.



CSi 300 Series Fast GC with Agilent Inert Mass Selective Detector

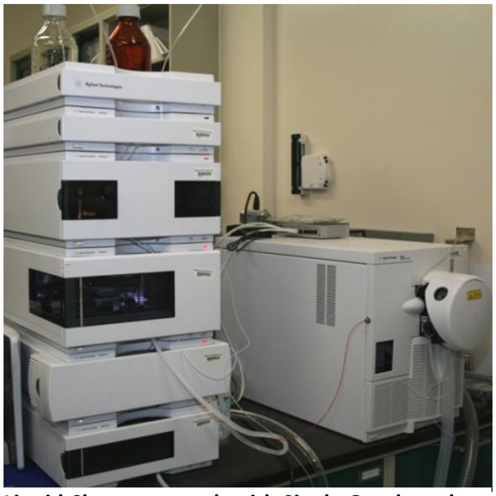
- FLD utilizes a Xenon lamp to excite an organic sample and break up the emitted fluorescence light with a fluorescence monochromator. It extracts the required fluorescence wavelengths (200 to 750 nm) and measures the intensity with a photomultiplier to confirm, identify, and quantify compounds.

Capillary Electrophoresis (CE) System – The Agilent Capillary electrophoresis G1600A system allows mixture separation of charged compounds based on their migration according to size-to-charge ratio under the influence of an applied electric field.

Electrophoretic separation is optimized by varying voltage (1.0 to ±30 kV) and current (<300 µA), and by applying different mechanisms of CE modes. Multi-sample sequence analyses can be programmed using the 48-position autosampler at controlled temperature from 10^{o} to 40^{o}C. Chemical detection is achieved using a real-time UV/Vis diode-array detector which ranges from 190 to 600 nm. Potential test support capabilities include any UV-absorbing CWA mixture separation and identification upon methodology development.

Mass Spectrometry

Mass spectrometry is an analytical technique used to determine composition of elements within a sample or molecule. Mass spectrometers ionize chemical compounds to generate charged molecules or molecular fragments and measure their mass-to-charge ratios. Mass spectrometry instruments are interfaced with gas or liquid chromatography systems for chemical mixture analysis.



Liquid Chromatograph with Single Quadrupole LC/MS

Gas Chromatography/Mass Spectrometry (GC/MS) – Ten GC/MS instruments are used for chemical compound confirmation, identification, and quantification, most of which are also equipped with flame ionization detectors (FID) and flame photometric detectors (FPD). GC/MS instrumentation includes six electron impact (EI) mass spectrometers and four electron impact-chemical ionization (EI/CI) mass spectrometers; one unit features Gerstel autosamplers with 96-position trays and headspace and solid-phase microextraction (SPME) sampling capabilities. The instrument specifications include: inert ion source for compound ionization; hyperbolic quadrupole mass analyzer for maximum transmission and resolution; scanning capabilities up to 2,000 amu/sec.; 1050 amu mass range; synchronous SIM/Scan with automatic setup; SemiQuant software for fast compound quantification, and deconvolution reporting software with retention time-locking databases.

Single Quadrupole LC/MS – The Single Quadrupole LC/MS instruments (two) utilize four parallel cylindrical rods. By adjusting the voltage and current applied to the rods, the instruments permit only ions of a given mass-to-charge ratio (m/z) to traverse the quadrupole and reach the detector; all other

ions are rejected. Testers can determine the absolute amount of a compound in a given sample and use scan speeds up to 10,000 u/sec. The instrument has a 3000 amu mass range and 1 pg sensitivity, with switching speeds as low as 20 ms.

Triple Quadrupole LC/MS System – Combines three single quadrupole units in a series, with the first quadrupole functioning as a mass filter, the second as a collision cell, and the third as a mass analyzer for the resulting fragmentation products. This configuration enables single reaction monitoring (SRM) studies which allows technicians to quantify and identify a given ion. The system initiates multiple reaction monitoring (MRM) rates of 150 compounds per second, with a minimum dwell time of 1 millisecond (ms). It detects a mass range of 5 to 2250 amu with a scan speed of 5200u/sec. and mass resolution of 0.5 Da.

Ion Trap LC/MS System

Ion Trap LC/MS System – The CCTF has two instruments coupled to a high performance liquid chromatography system (HPLC) – an atmospheric pressure ion source and the ion trap mass spectrometer. The instruments are used to break down molecules for structural and sub-structural identification. An HPLC pump (for quantification analysis) or a syringe pump (for method optimization) introduces samples to the ion trap electrospray interface which accepts flow rates up to 1 mL/min. to generate ions; ion optical elements guide the ions from the interface to the mass analyzer (ion trap). The ion trap collects the ions and then releases them according to their mass-to-charge ratio. The ion detector (including electronics, firmware, and software) converts the ions to a mass spectrum with electron transfer dissociation (ETD) fragmentation ranging from 40 to 100 m/sec. The ion detector produces an electrical current to record the mass spectrum. From the ramp rate, the intensity versus time profile is converted into a mass spectrum. The conversion utilizes a calibration file to ensure good mass accuracy.

Time of Flight (TOF) LC/MS – Measures the mass-to-charge ratio (m/z) based on the time it takes a packet of ions to reach the detector (its “time-of-flight”). TOF provides full-scan MS spectra (20 spectra/sec. from m/z of 100 to 3000, or 40 spectra/sec. from m/z of 100 to1000) with no loss of sensitivity. It detects across the entire mass range (50 to 12,000 m/z) rather than looking at specific values. Coupled to a high performance liquid chromatography system (HPLC), its high mass accuracy (<2 ppm), resolution (>13,000) and sensitivity are used for compound identification and quantification.

Spectroscopic Instrumentation

Spectrochemical analysis measures intensity of radiation absorbed, emitted, and scattered due to interaction of chemical species with electromagnetic radiations. The CCTF is equipped with a wide array of spectroscopic-based instrumentation to perform ultraviolet and visible molecular absorption, emission, and molecular vibrational analyses. Applications of spectrochemical analysis can range from classification, functional group identification, elemental structural association, and quantification.

600 MHz NMR interfaced with LC and micrOTOF-Q mass spectrometer

Nuclear Magnetic Resonance (NMR) Spectrometer –The 600-MHz superconducting magnet (14.1 Tesla) integrated with a CryoProbe™ system, operating at low temperatures, provides high resolution and high sensitivity for analyzing CWA, simulants, TIC/TIM, and other industrial chemicals. This NMR spectrometer is used to perform quantitative analysis for CWA purity determination as well as for structural determination of unknown compounds in liquid phase.

LC-(SPE)-NMR/Mass Spectrometer – A Liquid Chromatograph (Agilent 1200 series) is integrated with a microTOF mass spectrometer (Bruker Daltonics) and NMR to enable analyzing complex mixture compounds. HyStar™ software permits on-line analyses by introducing chromatographically separated analytes to NMR and mass spectrometer concurrently. With methodology development, structural information acquired from NMR would correlate with mass spectra of the eluted peaks providing the exact mass of an analyzed sample. Off-line NMR analyses can be performed by collecting separated analytes into multi-loops or by enriching the analytes into solid phase extraction (SPE) system for chemical enrichment using non-deuterated solvents during chromatographic separation.


Nicolet Almega XR Dispersive Raman Analysis System

Raman Spectrometer – The Nicolet Almega XR Dispersive Raman Analysis System (Thermo Fisher Scientific) is used to perform microanalysis of solid and liquid chemicals using an integrated microscope with high spatial resolution (≈1 micron). This system also offers macroanalysis of chemicals by directly sampling through a glass bottle (at high concentrations) as well as sampling chemicals on any substrate including glass and metal. Depending of the chemical of interest, 785 nm and 633 nm lasers are available for excitation with a spectral range of 100 to 4000 cm^{-1}. Applicable chemicals are CWA, simulants, and TIC/TIM. The spectral information obtained from this Raman system is complementary to infrared (IR) spectroscopy.

FT-IR Spectrometer - Nicolet™ 6700 FTIR spectrometer (Thermo Fisher Scientific) is interfaced with a Nicolet™ Continuμm™ microscope and liquid nitrogen-cooled MCT (mercury cadmium telluride) detector. OMNIC™ and Atlμs™ software controls the system data collection and processing spectrum. The system enables transmission analysis, reflection analysis, and limited fluorescence microscope analysis of samples that are <100 μm in size. Applicable samples include CWS simulants and TIC/TIM on paint chips, metal objects, tapes, and samples of various particle sizes. The system can identify functional groups of unknown substances and provides visual images of the substance distribution on a surface in a nondestructive manner.

Inductively-Coupled Plasma-Mass Spectrometer (ICP-MS) – This Agilent 7500 series instrument performs multi-elemental analysis utilizing an Octopole Reaction System (ORS) technology to remove interferences independently of the analyte and independently of the sample matrix. It is capable of analyzing unknown samples without requiring matrix-specific or element-specific optimization, and without requiring any interference correction equations. The ICP-MS is used for chemical compound confirmation and identification and is capable of determining a range of metals and some non-metals at concentrations below one part per 10^{12}. It can simultaneously measure most elements in the periodic table and determine analyte concentration to the sub-nanogram per liter or parts per-trillion level.

Inductively-Coupled Plasma-Mass Spectrometer

Steady-State Spectrofluorometer – The Photon Technology International QuantaMaster™ series fluorometer is equipped with a continuous wave Xenon arc lamp as an illumination source. Any fluorescent – CWA, simulants, and TICs – can be identified qualitatively by performing excitation and emission spectral analyses. Steady-state time-based liquid chemical analysis under various temperatures, ranging from 5^{o} to 70^{o}C, can also be performed using a built-in Peltier temperature controller. A solid sample holder is available to permit analysis of thin polymer film on solid substrate.

UV/Visible Absorption Spectrophotometer – 8453 Agilent UV/Vis spectrophotometers use both deuterium and tungsten lamps as excitation sources and measure the resulting absorption over the wavelengths (200 to 1000 nm), which is detected using a photodiode array (PDA). The spectrophotometer is also equipped with autosampler standard racks for high throughput analysis. The system can be used for chemical identification of any UV absorbing CWA, CWA simulants, and industrial chemicals. This system is the primary method to quantify contamination density of CWA simulants up to 90 g/m^2 when disseminated onto filter paper during field trials.

Laser Diffraction Particle Size Analyzer– Malvern Spraytec measures the mass median diameter of high concentration aerosols and sprays in real time using a laser diffraction technique. The analyzer measures a broad range of droplet sizes ranging from 0.1 to 2000 microns. Droplet size distributions of either pulsed or continuous spray sources can be characterized from the angular intensity of light scatter from the source when the aerosol passes through a laser beam. The scattering pattern is then fit into multiple scattering algorithms and appropriate optical models to yield a size distribution. A fast data acquisition rate (10 kHz) permits analysis of the dynamics of spray dispersion along with size distributions.

Additional Instrumentation

Immersion Chamber – Designed to test and evaluate multiple point detection systems with chemical warfare agent simulant challenges in a controlled laboratory environment and prior to field testing. (See **Immersion Chamber** for additional information.)

Miniature Chemical Agent Monitoring System (MINICAMS®) – MINICAMS® are used for laboratory safety air monitoring and the detection of GA, GD, GB, VX, HD, and Lewisite fumes, plus fumes from chemical simulants. MINICAMS® when coupled with a flame photometric detector (FPD) can detect TEP to 0.00005 mg/m^3. A development program is currently in process to couple MINICAMs® with ion mass spectrometry (IMS) to detect MeS at 0.0001 mg/m^3.

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Section 6

Munitions Testing

Smoke & Obscurants

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Munitions Testing

Division: *Dissemination & Explosives* **Branch:** *Explosives Test*

Capability Summary

Munitions testing within the vast terrain at Dugway Proving Ground (DPG) dates back to World War II when such activities were conducted alongside the installation's primary mission of chemical-biological (CB) defense testing. Today, the West Desert Test Center (WDTC) continues to operate and maintain munitions test sites, firing ranges, and bunkers to test and evaluate modern artillery munitions, mortars, mines, insensitive munitions, homemade explosives (HME), and improvised explosive devices (IED).

Trained weapons operators and munitions handlers deploy, operate, and maintain weapons systems to support munitions test programs, including handling of munitions, ammunition, and ammunition components, as well as performing dynamic tests to simulate handling or transportation, and subjecting munitions to various environmental conditions.

Certified gunners and weapons operators are responsible for weapon and support equipment inspection and preparation, transport to firing locations, alignment, loading and operation, and responses to misfires. Certified explosives test operators (CETO) handle and transport explosives, prepare charges and firing circuits, detonate explosives, and collect explosives test data. Explosive ordnance disposal (EOD) technicians safely locate, recover, disassemble, and demilitarize munitions and unexploded ordnance (UXO) across the test range.

Capability Description

Dugway's test grids and ranges encompass over 900 square miles with many areas designated for testing munitions (e.g., German Village Artillery Range, White Sage Mortar Range, Illumination Grid) while outdoor chemical or biological tests may include explosives dissemination of CB simulants, or toxic industrial chemicals (TIC). See **Field Dissemination Systems** for additional information on dissemination by explosives.

Munitions receipt inspection

All munitions test operations begin with a receipt inspection and inventory of each test item to document any damage or missing components, determine discrepancies, and to obtain precise measurements, such as dimensions, weight, and other physical characteristics. Ammunition received may include separate-loading projectiles, separate-loading propellant charges, semi-fixed projectiles, semi-fixed propelling charges, and fuzes/plugs for required munitions.

Test items may undergo dynamic and environmental testing, as per MIL-STD-810G, to assess functionality following exposure to physical or thermal shock, vibration, high/low temperature extremes, humidity, altitude, precipitation, salt fog, sand, or dust. See **Dynamic and Environmental Testing** for capabilities descriptions.

The receipt, storage, and distribution of ammunition and chemical agents are provided under surety control procedures. Munitions and explosives placed into storage igloos or portable magazines must meet compatibility and explosive license requirements. Secure storage facilities segregate munitions based on volume or classification, including: top secret, classified, large quantity, and hazard class division 1.1 (mass explosion) and below. Portable magazines allow munitions and explosives storage at field testing and training locations throughout DPG.

Mobile munitions storage magazine

20-ton bridge crane inside maintenance facility

A 2800-squre-foot maintenance facility features a heavy-duty handling platform and 20-ton overhead crane to lift (up to 40 feet from floor to bridge), transport, and place munitions. Personnel can perform full maintenance on conventional and experimental towed and self-propelled artillery and mortar systems, including turrets and hulls on self-propelled systems. Explosives-certified personnel can perform fuze removal from, but not limited to: 60-mm, 81-mm, 4.2-inch, 120-mm, 105-mm, 155-mm, inert, smoke, high explosive, illumination, and other munitions.

Munitions Testing

Test officers collaborate with customers to establish a munitions test plan that may include: location of test, number of trials, test objectives, characterization requirements, dynamic and environmental tests, site preparation, sampling devices, instrumentation (including meteorological), personnel and specialized equipment requirements, test and data imaging, and data to be collected. Technicians and operators also provide support during military training exercises.

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Test setup for General Atomics' Blitzer™ electromagnetic railgun air defense prototype system

Railgun test fire projectile

Trained gun crews and weapons operators may deploy a variety of mortar systems, howitzers, or small arms during tests or provide test support to a customer's prototype system. High-speed video and still cameras record the test event at various angles; meteorological instrumentation such as sonic anemometers and Portable Weather Instrumentation Data Systems (PWIDS) record weather conditions; and instrumentation such as accelerometers and pressure probes collect data on acceleration at impact and blast pressure. Test support includes installing an array of witness panels to collect and capture fragments to determine fragment velocities, masses, and densities for characterization of a munition's effect at given distances within the test arena.

Munitions Recovery and Disposal

Trained explosives ordnance disposal (EOD) technicians locate and recover munitions in support of the DPG test and training mission. All unsafe munitions are disposed using open burn or open detonation of explosives procedures. Recovery operations include metal sweeps of impact areas and location of ordnance using an armor-plated backhoe or remote-controlled equipment.

TALON Robot and control system

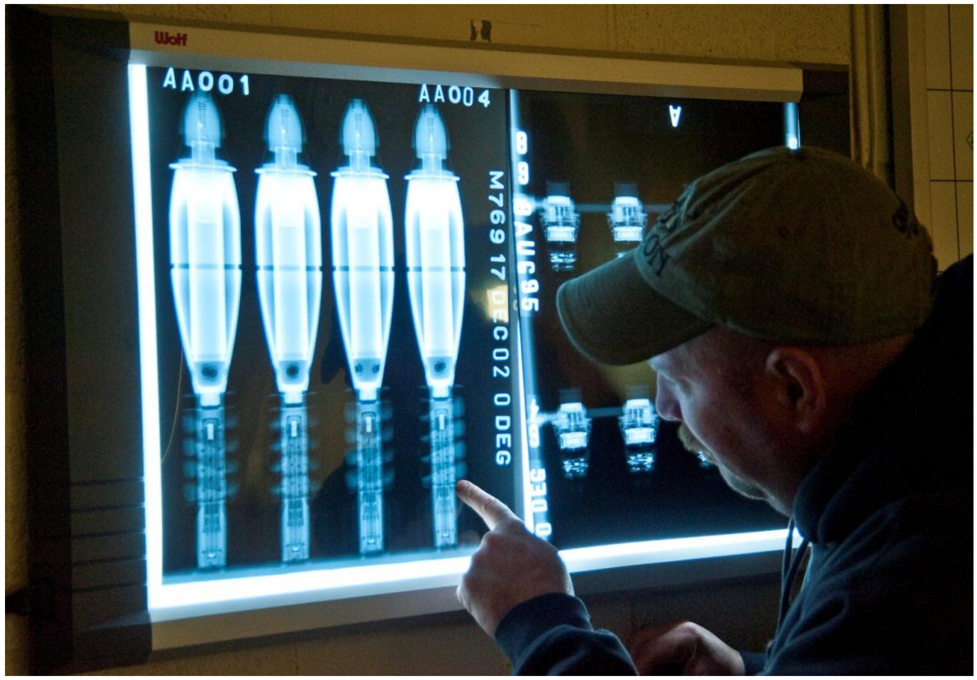
A robotic-controlled Bobcat® allows EOD personnel to excavate and recover unexploded ordnance (UXO) items of unknown explosive hazard that are below ground level. The Bobcat® utilizes seven cameras for non-line-of-sight operation, a microphone for ambient sound pickup, three CREW 2.1 compatible radio options, three control options, warning lights to signal robotic engagement, and emergency shut-off switches.

The TALON® Robot is a lightweight tracked vehicle that is used for EOD, reconnaissance, communications, CBRNE/hazmat, security, defense and rescue. The robot has all-weather day/night capabilities and can navigate virtually any terrain. The TALON® Robot supports munitions testing allowing EOD personnel to approach items of unknown explosive hazards, pick up and transport rounds, or to remotely place explosives for remote detonation.

Thermal treatment (open detonation, open burn) of munitions, bulk propellant, and explosives is performed at the Dugway Thermal Treatment Facility (DTTF) which can also provide thermal treatment of Resource Conservation and Recovery Act (RCRA) reactive waste (D003) materials. Technicians may perform open burn operations of up to 1000 lbs per event, net explosive weight, and up to 3000 lbs per day (maximum of 30,000 lbs per rolling 12-month period). For open detonation operations, up to 1500 lbs per event (1500 lbs per day) is permitted with a maximum of 150,000 lbs per rolling 12-month period.

Non-Destructive Testing and X-ray Capabilities

Non-destructive test (NDT) equipment provides the capability to inspect and analyze artillery and mortar munitions, fuzes, and mortar tubes for flaws and imperfections and can be used to determine causes of munition malfunctions.



A technician inspects images of the M769 Full Range Practice Cartridges (FRPC)

The Dugway X-ray facility (Building 3236) features four radiographic systems with a capability to penetrate up to 10 inches of steel to analyze dud munitions or other any Dugway equipment. Certified radiography technicians take and develop (chemical and digital) X-rays to produce a view of the munition's interior to determine if is damaged, properly fuzed, or contains a solid or liquid fill. Mobile X-ray and film processing equipment allows for inspection and identification of munitions in the field, and the digital measuring equipment allows precise measuring of a variety of munitions ranging from 60 mm to 8 inches.

Quick Facts

Recent munitions tests supported at Dugway:

- Rocket ballistic flight test for BAE Systems of the five-inch Long Range Land Attack Projectile (LRLAP)
- Test firing the General Atomics' Blitzer™ Electromagnetic Railgun
- Accelerated lifecycle tests of the L96A1 anti-riot grenade discharger
- Patriot Missile long-term storage and aging

Smoke, Obscurants, and Interferents

Division: *Dissemination & Explosives* **Branch:** *Smoke & Obscurants*

Capability Summary

Tactical use of smoke and obscurants has been employed by the military in every major international conflict since World War I and is considered to be a powerful combat multiplier. As military operations and obscurant technologies continue to change in the 21st century, Dugway Proving Ground (DPG) is primed to be the center of cutting-edge obscurant test programs.

The West Desert Test Center (WDTC) enlists a full range of equipment, facilities, and expertise to test smoke and obscurant producing munitions. In addition, scientists and test officers utilize smoke, obscurants, and battlefield interferents to:

- Test effects of smoke and battlefield interferents on chemical and biological detection systems
- Test effects of smoke and interferents on air filtration systems
- Provide visual confirmation of airflow mapping tests and smoke/obscurant modeling

In addition, certified gunners, weapons operators, and explosives test operators can support operational tests and military and National Guard training exercises by deploying smoke and obscurants on the open battlefield or within an urban combat environment.

Capability Description

The West Desert Test Center features a unique geographic landscape of flat desert, mountains, caves, and tunnels which are combined with indoor test facilities and environmental conditioning and dynamic test chambers (see **Dynamic and Environmental Testing**) to allow the testing of new and fielded smoke and obscurant producing munitions.

Smoke and Obscurant Munition Developmental Tests

Trained and certified Dissemination and Explosives (D&E) technicians perform developmental tests on smoke-producing grenades and projectiles to evaluate the functionality under the types of conditions that may be encountered in today's war zones.

Test officers assist customers with the development of a test program for smoke/obscurant munitions that may include operation and performance measurements following exposure to:

- Ambient, hot, and cold temperatures
- Seven-day hot/dry storage and three-day cold storage
- Repeated hot and cold temperature shifts
- Low or high humidity
- Vibration in both a secured condition and loose or unpackaged condition
- Rough handling simulations or drop tests up to 40 feet
- Sand, dust, water immersion, salt fog, or fungal growth


Cold storage test of M98 mortar system

Additional tests may include assessing the reaction to a slow heating environment (slow cook-off test), rapid heating environment (fast cook-off), and deliberate bullet or projectile attacks (bullet impact test).

Test officers can determine if the munition provides adequate reliability characteristics and determine if any health or safety hazards arise resulting from handling, transportation, and use in ambient, hot, and cold environments. Human engineering design and soldier-equipment interface characteristics may also be assessed.

Certified operators fire smoke/obscurant munitions from: 66mm grenade launchers secured to armored or non-armored tactical vehicles, grenade launchers secured to custom-built trailers or platforms, Light Vehicle Obscuration Smoke Systems (LVOSS), artillery, or thrown by hand. A smoke obscuration effectiveness test can measure a smoke screen in terms of size, rate, density, and duration of the smoke for visible obscuration.

High definition photographic and video recordings capture fuze delay time, time of function, time of flight, range of burst, height of burst, deflection, and time to obscuration (heavy and total). A Dynamic Cloud Target Obscuration Measurement System (DCTOMS) provides post-test video stream processing to measure luminance and to calculate obscuration effectiveness data. Meteorological instrumentation captures temperature, humidity, wind speed, and direction during open-air trials and bullet impact tests.

An indoor trial may utilize closed-circuit television cameras with data processed within the Mobile Image Processing System (MIPS) laboratory trailer which features fast delivery of large streams of photonics images and data products. The MIPS trailer supports quick-look data delivery and some real-time data presentation of events recorded by the optical acquisition systems.

Operational Testing and Military Training Support

WDTC D&E personnel can support operational tests and military training exercises in open-air battlefields, simulated urban settings, or other military scenarios. Operators can launch projectile or canister-type smoke-producing munitions to obscure, screen, deceive, block infrared or electronic signals, or to provide signals to allies during maneuvers.

XM-106 smoke grenade test

D&E personnel support testing and training requirements through the emplacement, loading, firing, and dud recovery of a variety of smoke-producing munitions, such as, but not limited to:

- 66mm Smoke Grenades
  - M76 Infrared Smoke Grenade
  - Modified M81 Infrared and Radar Smoke Grenade
  - Modified M82 Smoke Grenade
  - M90 Smoke Grenade
- 66mm Anti-Riot Grenades
  - L96A1 CS Grenade
  - L97A1 Practice Grenade
  - M98 Nonlethal Distraction Grenade
  - M99 Nonlethal Blunt Trauma Grenade
  - M6 Riot Control Grenade
- Interferent Smoke Grenades
  - M15 – White phosphorus (WP) smoke grenade
  - M18 – Colored smoke grenade (red, yellow, green, or violet)
  - M8 – Hexachloroethane (HC) white smoke grenade
- ABC-M5 Smoke Pots
- M56 smoke generator

Smoke grenades can be launched from systems mounted to armored M1A1 Abrams Battle Tanks, Highly Mobile Multipurpose Wheeled Vehicles (HMMWV), pre-fabricated trailers, or custom-built platforms. Burn time for grenades typically range between 60 and 90 seconds.

Smoke from HMMWV

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Dissemination of Interferents/Contaminants for Chemical-Biological Tests

DPG is permitted to release large quantities of simulants under controlled conditions on its test grids and training ranges. D&E technicians and operators assist chemical and biological (CB) test officers with the development and implementation of test plans to disseminate interferents and battlefield contaminants (BFC) to meet a customer's test requirements.

Interferents or BFCs are used primarily in developmental testing of CB detection systems on the test grids or within the Joint Ambient Breeze Tunnel and Ambient Breeze Tunnel. Air filtration systems are tested in the Advanced Air Purification Test Fixture, Building 3445. Light Detection and Ranging (lidar) systems are used as test standoff referee systems and can identify interferent used and start/stop times of dissemination.

Interferents may be released simultaneously with biological simulants to evaluate the ability of a system under test (SUT) to detect simulants in the presence of interferents. Interferents may include: white or colored smoke; burning wood, rags, vegetation, diesel fuel, or rubber; fog oil; road dust; diesel exhaust; or kaolin.

Chemical detector systems are evaluated on their sensitivity to chemical simulants in the presence of BFCs, while air filtration systems are evaluated on their ability to remove BFCs, which may include:

- N,N-Diethyl-meta-toluamide (DEET)
- Jet Propulsion 8 fuel (JP-8)
- Fog oil
- Aqueous film-forming foam (AFFF)
- Hydraulic fluid
- Antifreeze
- Wasp spray
- Bleach

Quick Facts

Recent test programs utilizing interferents at Dugway:

- 155mm DM125 Smoke Effectiveness Test
- Aerosol Modeling Study, Joint Biological Standoff Detection System (JBSDS), Increment 2
- Indoor Performance Test Comparison of Modified M106 Grenade
- Technology Evaluation of the Chemical Biological Detection System (CBDS)

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Section 7

Dugway Test Support

Field Dissemination Systems

Division: *Dissemination and Explosives* **Branch:** *Dissemination*

Capability Summary

U.S. Army Dugway Proving Ground (DPG) maintains the required environmental permits and certifications to disseminate chemical and biological (CB) simulants, plus toxic industrial chemicals/toxic industrial materials (TIC/TIM), for outdoor field testing of individual and collective protection systems, and CB point and standoff detection systems. In addition, simulant dissemination is used to measure the survivability of military equipment and systems following decontamination.

The West Desert Test Center's (WDTC) multitude of field dissemination systems can generate simulant clouds under stationary, mobile, and aerial conditions, as well as through a variety of detonation methods. The Dissemination and Explosives Division has the capability to produce smoke, diesel exhaust, and other battlefield obscurants in combination with CB simulants.

Dissemination specialists can produce a variety of CB simulants in liquid, vapor, aerosol, or powdered form, including: diethyl ethylphosphoate (DEEP), triethyl phosphate (TEP), methyl salicylate (MeS), sulfur hexafluoride (SF6), and wet-aerosolized or dry *Bacillus atrophaeus* (BG), E*rwinia herbicola* (EH), and ovalbumin (OV). Small to large quantities of TICs, such as chlorine and ammonia, may also be disseminated on the Dugway test grid.

System Descriptions

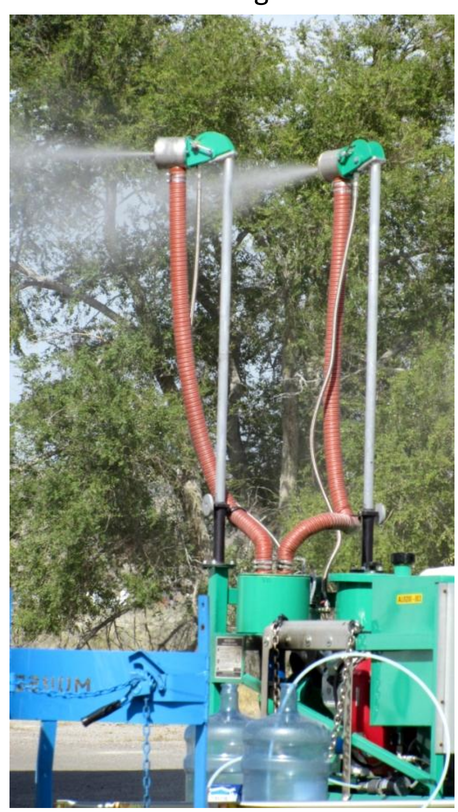
Test officers may utilize multiple dissemination systems and methods depending on customer and test requirements. Special dissemination systems can be designed and fabricated in-house to meet test-specific needs.

Liquid Dissemination

Micronair disseminators can be vehicle-mounted or worn as a backpack, and a pump system can be fitted to the unit to increase accuracy of the release. Capable of point or line source dissemination, Micronair sprayers can release 50 to 500 mL of bio-liquid simulant per minute from 12 L tanks. An electric Micronair is used exclusively in the Joint Ambient Breeze Tunnel and Ambient Breeze Tunnel for disseminating low flows of liquid biological simulant, from 1 to 60 mL per minute. The Micronair AU9200 agricultural sprayers feature dual spray nozzles and have been integrated with microcontrollers, sensors, and network interface, to allow remote operation on the test grid.

The line source Spinning Disk Disseminator spreads an array of thickened (low viscosity) chemical liquid simulant, usually on roadways. A vehicle-mounted or stationary system, the spinning disk produces droplet sizes ≤500 µm at a concentration as low as 0.5 g/m².

Aerial disseminations over the test grid can provide low-level releases of thickened chemical simulant. Helicopters, available from Yuma Proving Ground, are fitted with either a Spray-King system or with a specially-built dissemination system mounted under the helicopter's fuselage, with storage tank and pumps located inside the helicopter cabin. The Spray-King system is a self-contained, engine driven liquid bucket system that is independent of the airframe except for the controls which attach to the cycle control stick.



Micronair AU9200 sprayers

Vapor Dissemination

Dugway's two point-source fixed disseminator stacks and two portable stacks are located at Target S and can be elevated from 0^{o} to 90^{o}. The 70-foot (12-in diameter) insulated mild steel stacks, utilize heated air forced into the bottom of the stack by an Air Start Unit MSU 200T. The stacks can produce 10 kg of a chemical

Portable stack

simulant (e.g., TEP, MeS) cloud in one minute, or sustain 6 kg/minute (≈6 L/min.) for approximately 30 minutes, depending on the fuel for the MSU unit. Extended disseminations of vapor clouds up to six hours are also possible using a lower flow rate.

The Portable Vapor Dual Stack System, designed and fabricated at Dugway, pumps chemical simulant through sonic nozzles and mixes with air heated to 200°C, creating a simulant vapor that flows through the dual stacks. Designed for small quantities of simulant (≤200 mL/min.), this point or line source disseminator produces a droplet size of approximately 20 µm.

Aerosol Dissemination

Chemical Aerosol Carts are portable (stationary or vehicle mounted) simulant disseminators that feature a variety of cyclone nozzles. Used as a line or point source disseminator, the system can be elevated to 20 feet and produce droplets ≤10 µm.

The Chemical Aerosol Portable System provides the flexibility of being set up as a stationary unit or can be mounted to any vehicle. The system uses a variety of cyclone nozzles to produce droplet sizes of ≤10 µm.

Micronair disseminators can release bioaerosol simulants in the field, or be used in a controlled environment, such as the Ambient Breeze Tunnel. In chamber tests, Micronair disseminators can generate both step clouds and a Gaussian cloud in intervals of two, three, five, and 10 minutes.

Powder Dissemination

Dugway's two agricultural sprayers can release up to 10 pounds of dry BG simulant per minute, producing a high-volume cloud. The truck/trailer mounted sprayer can be used for line or point release.

Air cannon disseminators generate an instant release of dry biological simulant which can elevate to a height of 30 feet, depending on surface winds. Primarily used as a point source disseminator, the three sizes of air cannons can release between 50 and 300 grams of powdered simulant.

Skil® blowers disseminate powdered biological simulant for large or small releases. Used for line or point source dissemination, Skil® blowers are powered by a 3000-watt generator and can release dry bio-simulant ranging from 0.2 grams to 13 grams per minute.

Two converted Micronair units can disseminate approximately 10 lbs of dry CB simulant each.

Dissemination by Explosives

Dissemination by explosives may be a single-point detonation of 1 to 55 gallons of chemical simulant, or small quantities launched from the Simulator Projectile Airburst Liquid (SPAL) system. For single-point detonations, explosive operators typically use a ratio of 1 lb of Composition 4 (C-4) explosives for every 4 lbs of simulant, up to 60 blocks for a 55-gallon container.

Simulator Projectile Airburst Liquid (SPAL) system

The trailer-mounted SPAL system consists of short launch tubes containing simulant-filled canisters and bursters. SPAL containers can be launched from a moving vehicle (1 to 10 mph) via the firing box located in the cab. Canisters explode at a predetermined height, disseminating up to one liter of chemical or biological simulant, such as acetic acid (AA), MeS, TEP, SF6, and *Bacillus thuringiensis* (Bt). The SPAL system can disseminate up to 100 grams of dry biological simulant, such as BG and OV.

Ammonium nitrate/fuel oil (ANFO) explosives may be used to detonate CB simulants from a particle-dispersal device (PDD) or a fluid-dispersal device (FDD). The PDD and FDD can be mounted to wooden towers or other elevated sacrificial structures for above-ground detonations. Simulant plumes have been created to test the WMD Aerial Collection System (WACS), mounted to an unmanned aircraft system (UAS), which located and interrogated the plumes.

The air burst artillery simulator creates an air explosion of chemical or biological simulants at 500 feet representing a real-world threat and is used in the methodology stage of a test.

Dissemination of simulant triethyl phosphate (TEP) by explosives during a test event...before, during, and after

Environmental conditioning chambers

Dynamic and Environmental Testing

Division: *Test Engineering and Integration* **Branch:** *Engineering*

Today's warfighter must rely on materiel and equipment that is operationally ready worldwide despite being subject to a multitude of physical and environmental stresses that each item may encounter during its life cycle. Stresses can include equipment deterioration from handling, transportation, open or closed storage, and deployment by soldiers and ground personnel in land vehicles, or aboard ships and aircraft. The U.S. military operates in all climates, including tropical, arctic, and arid locations, where materiel and equipment may be subject to extremes of heat, cold, precipitation, wind, salt water, fog, dust, and sand.

The Department of Defense Test Method Standard, "Environmental Engineering Considerations and Laboratory Tests" (MIL-STD-810) is the standard for all DoD departments and agencies that requires, as part of the acquisition process, tailoring an item's design and engineering criteria to environmental conditions that the materiel or equipment will experience throughout its service life. The test and evaluation community develops methods and conducts tests that replicate the effects of environmental stress to ensure each item will function as required.

A Dugway technician makes an adjustment to the refrigeration system of a Series 300 environmental conditioning chamber

The West Desert Test Center (WDTC) maintains 40 environmental conditioning chambers to subject materiel and equipment to extremes caused by physical forces (e.g., vibration, shock, and drop) and the environment (e.g., temperature, humidity) in both cyclic and steady-state conditions. Five specialty chambers are available to test the effects of fungal growth, salt fog, altitude, vibration, and time and temperature reactions of munitions (slow cook-off).

Mobile and skid-mounted chambers which replicate the extremes of climatic environments may also be subject to dissemination of environmental or battlefield contaminants, such as fog oil or jet propulsion fuel (JP-8), during testing. Dynamic and environmental tests may be video recorded while photographs are taken to capture the results of each test. Scientists, test officers, and analysts perform data acquisition, measurement, control, and analysis with National Instruments LabVIEW software.

Dynamic Tests

Vibration/Shock/Loose Cargo – Vibration testing determines how a test item can both function in and withstand vibration exposures during its life cycle, including environmental effects, materiel duty cycle, and equipment maintenance. The physical test chamber and bounce table are housed within the Vibration Test Building, located at the Carr Test Support and Storage Complex, and are certified for testing high explosive munitions.

Technicians secure a pallet of encased detectors inside the vibration chamber prior to test

The 9x7x9-foot physical test chamber features a 5x5-foot vibration table for test items up to 6,000 pounds and utilizes a two-inch displacement generating up to 38,000 pound-force for high-intensity shock tests. The physical test chamber allows vibration testing under varying temperature (-100^{o} to 200^{o}F) and humidity (5% to 98%) conditions. The 6X8-foot loose cargo transportation simulator (bounce table) provides a one-inch circular orbit (up to 300 rpm) to test an item's ability to withstand transportation over rough terrain. Certified technicians analyze the dynamic deflections of or within the material which may cause or contribute to structural fatigue and mechanical wear of structures, assemblies, and parts.

The wide-frequency band shaker is an electrodynamic, 15 to 18 kip-force shaker/vibrator with a 2-inch maximum displacement. The shaker operates in a 5 to 3000 Hz frequency range with sine or random waves converting electrical current to mechanical force using a magnetic structure.


A technician times a loose cargo test

Drop Tests – The Drop Tower Test Facility is used to analyze the impact of single or multiple test items that have been packaged and palletized. Dugway technicians conduct drop/drag testing of ammunition, ammunition components, and equipment in accordance with MIL-STD-331, International Test Operations Procedures (ITOP) 504, and ITOP 602.

Drop tower

The drop tower allows for controlled altitude free-fall drops at any desired height up to 40 feet. The facility includes a control room bunker, observation bunker, and steel, concrete, and earth drop surfaces. Remotely-controlled cameras record drop, free-fall, impact angles, altitude measurement, and damage assessment. The facility permits testing of packages up to 5 cubic feet and weights up to 3,000 pounds, with maximum loads of 250 pounds for high explosives, and monitoring of an item's "G" impact force. The facility has been used to test projectiles, grenades, artillery and mortar fuses, and mortar refurbishment kits. One-ton containers, mines, and M40/42 protective masks have also been tested at the drop tower facility.

Technicians perform damage assessments to determine if the items are packaged properly, and for munitions and explosives, record whether the test item exploded, burned, lost propellant or is safe to handle.

Slow Cook-Off – The slow cook-off test determines the time and temperature at which a test cartridge (one round bare and one round in shipping overpack) or other energetic item will react when submitted to a gradually increasing thermal environment. Certified test personnel conduct slow cook-off tests inside an impenetrable conditioning chamber housed within a mobile, 10x10x10-foot custom-built trailer. The conditioning chamber has a heating capacity from 70° to 700°F and each test item is subject to increasing temperatures at a rate of 3.3°C (5.9°F) per hour until a reaction occurs. Once the reaction occurs, the elapsed time of heating component parts (e.g., fin assembly, fuse, and burster) is recorded along with the time/temperature relationship, cratering, and fragment size to indicate degree of reaction.

Environmental Tests

Altitude (Low Pressure) – Altitude tests determine if materiel can withstand or operate in a low pressure environment, or withstand rapid temperature changes. The Altitude Chamber is located at the Carr complex and can create atmospheric pressure ranging from sea level to 100,000 feet. The 4x4x4-foot chamber can be used to test explosives in a temperature-controlled environment ranging from -70° to 200°F with a gradient of less than ±3°F at any point 3 inches from the walls, floor, or roof. Certified technicians examine the effects of altitude on test items that may include: leaks from gasket-sealed enclosures, deformation/rupture of sealed containers, evaporation of lubricants, and operational malfunctions of mechanical/electrical components.

Altitude chamber

High and Low Temperature – Testers evaluate the potential effects of high and low temperature conditions on materiel safety, integrity, and performance during storage, handling, and operations. The WDTC employs 13 fixed and 7 mobile chambers each able to achieve temperatures between -100° and 200°F with a gradient of less than ±3°F at any point 3 inches from the walls,

200 series mobile conditioning chamber

floor, or roof. The chambers have a heating capacity to raise the temperature from -100°F to +200°F in less than 6 hours when filled with up to 500 pounds of steel. All operating conditions can be obtained and maintained at any ambient temperature between -10° and 110°F.

Four fixed chambers (12x8x8 ft) are located at the Carr complex; the nine large (25x8x8 ft) chambers are located at the White Sage Mortar Range and at German Village. Mobile temperature chambers (12x7x7 ft) can be transported to any test location and all chambers are certified to test explosives. Tests determine whether temperature extremes temporarily or permanently impair performance of materiel by changing physical properties or dimensions, such as:

- Materiel parts bind, harden, or become brittle
- Lubricant viscosity changes
- Failure of packing, gaskets, seals, bearings and shafts
- Changes in electronic components
- Changes in burning of explosives or propellants

Conditioning chambers are also used for temperature shock testing (sudden air temperature changes >10^{o}C or 18^{o}F) and accelerated aging tests of stored materials.

Humidity – Testers can determine resistance of materiel items or equipment to humid conditions that may be stored or deployed in warm, humid environments, in addition to finding indicators of potential problems associated with humidity. The WDTC has 17 mobile conditioning chambers (12x7x7 ft) to create relative humidity (RH) conditions ranging from 3% to 97%; six chambers generate temperatures between 15^{o} and 200^{o}F and 11 chambers have temperature capabilities between -100^{o} and 200^{o}F. All operating conditions can be obtained and maintained at any ambient temperature between -10°F and 110°F. Heating and cooling are generated by electrical heaters, mechanical refrigeration, and injection of refrigerant.

Certified technicians analyze the effects of humidity on materiel including:

- Surface changes, such as oxidation, increased chemical reactions, and chemical or electrochemical breakdown of organic and inorganic surface coatings.
- Material property changes, including swelling, loss of physical strength, changes in elasticity or plasticity, and degradation of explosives and propellants by absorption.
- Condensation and free water causing electrical short circuits, fogging on optical surfaces, and changes in thermal transfer characteristics.

Fungus chamber

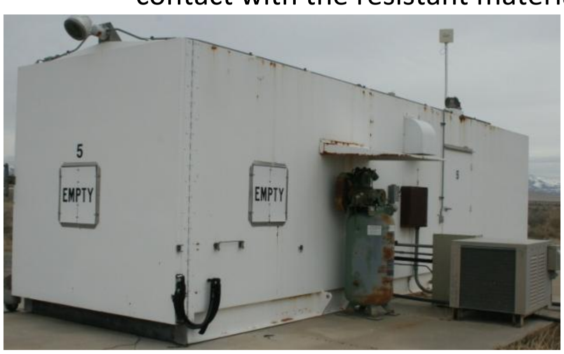
Fungus – Microbiologists conduct tests to assess the extent to which materiel will support fungal growth and how any fungal growth will affect

materiel performance or utilization. The fungus chamber (22x8x8 ft) is located at the Carr complex and generates up to 98% RH at temperatures ranging from 15° to 200°F, with a gradient of less than ±3°F at any point three inches from the walls, floor, or roof. Electric heaters, mechanical refrigeration, and direct injection of refrigerant are used to heat and cool the chamber. Mobile conditioning chambers are also used for fungal growth tests and evaluation.

Storage rack inside fungus chamber

WDTC microbiologists analyze the detrimental effects of fungal growth that may include:

- Direct breakdown of nonresistant materials and how the fungi use them as nutrients, such as:
    - Natural materials – Cellulosic materials, animal/vegetable-based adhesives, grease, oils, hydrocarbons, and leather
    - Synthetic materials – PVC formulations, certain polyurethanes, plastics that contain organic fillers of laminating materials, and paints/varnishes containing susceptible constituents.
- Damage to fungus-resistant materials from an indirect attack when:
    - Fungal growth on surface deposits, such as dust, grease, perspiration, and other contaminants causing damage to underlying material.
    - Metabolic waste products excreted by fungus causing metal corrosion, etching of glass, or staining/degrading plastics and other materials.
    - Products of fungus on adjacent materials that are susceptible to direct attack come in contact with the resistant materials.



Salt fog chamber

Salt Fog – Salt fog tests determine the effectiveness and quality of protective coatings and finishes on materiel and material coupons, and to locate potential problem areas, quality control deficiencies, and design flaws in a short period of time. The salt fog chamber (12x8x8 ft) located at the Carr complex delivers a 5% salt solution mist (pH 6.5-7.2) to test items over a four-day test trial. Test operators alternate 24-hour salt mist applications with 24-hour drying periods under temperature-controlled conditions (15° to 200°F). Test officers and technicians analyze test items for:

- Corrosion effects – Electrochemical reactions, accelerated stress, and formation of acidic/alkaline solutions following salt ionization in water.
- Electrical effects – Impairment of electrical equipment, production of conductive coatings, and corrosion of insulating materials and metals.
- Physical effects – Clogging or binding of mechanical components and assemblies, and paint blistering resulting from electrolysis.

Salt solution tanks for salt fog

Light Detection and Ranging (LIDAR) Systems

Division: *Test Engineering & Integration*
Branch: *Test Data Imaging*

Capability Summary

The West Desert Test Center (WDTC) has developed and acquired a variety of Light Detection and Ranging (LIDAR) systems that serve as standoff referee instruments for test trials involving a release of a chemical or biological simulant cloud. Primarily used in conjunction with tests of candidate chemical-biological (CB) point detection systems, lidar can detect, track, and characterize vapor and aerosol clouds as they migrate across the test area without interfering with test conditions.

Lidar systems are typically placed in the field approximately three to six kilometers from the test site and track the exact location of the cloud path and concentration in real time for about 10 to 30 minutes, depending upon conditions. Lidar sends out pulses of laser light and measures the return signals of elastic backscatter versus range as the light pulse interacts with atmospheric molecules, chemical vapors, or particulate aerosol clouds. All lidar systems produce three-dimensional data from aerosol clouds through raster scanning.

Each lidar system is mounted inside a custom-built trailer allowing easy movement to any location on the test grid or can be transported to safari test locations. The trailers feature air ride suspension systems, heating and air-conditioning, and separate compartments for laser activity and computer operations.

System Description

The WDTC currently utilizes a variety of lidar systems of varying types which can be operated simultaneously on the same cloud to provide precise images and continuous tracking in the event cloud drift changes unexpectedly. Several systems have been custom designed and built by scientists, engineers, and technicians at the WDTC.

Raman-shifted Eye-safe Aerosol Lidar – The Raman-shifted Eye-safe Aerosol Lidar (REAL) utilizes a 1064 nm laser that is shifted to an eye-safe wavelength (1550 nm) using a gas-filled Raman cell. Its output average power at the eye-safe wavelength is between 1 and 5 watts. The scanner uses slip-rings that allow both the elevation and azimuth to rotate continuously. The minimum useful range is 600 meters and the maximum range can be set by the operator.

REAL is used as a referee system during biological field trials in which eye-safety is a requirement. REAL's return signal is composed of elastic backscatter from aerosol particles. REAL's output wavelength lies within the safest band in the optical spectrum; therefore photons are safely absorbed

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in the aqueous and vitreous humor of the eye. This system provides real-time data analysis and plotting which can be viewed within the system as well as at a remote command post location during testing. This system uses a 16-inch collection telescope.

Laser Induced Fluoresce Lidar – The Laser Induced Fluoresce (LIF) Lidar is a custom-built system based on a Contiuum® 9030 laser with a fundamental frequency of 1064 nm and average power of 48 watts (typically operated at up to 9 watts average power). The laser pulse repetition rate is 30 Hz; the scanner is capable of 0° to 360° in azimuth and -5° to 180° in elevation.

West Desert Lidar

LIF is used to referee biological simulant aerosol clouds during tests and has a minimum useful range of 600 meters with a 1.5 km to 48 km maximum range. The return signal is composed of elastic backscatter from aerosol particles and provides real-time data analysis and plotting which can be viewed within the system as well as at a remote command post location. This system uses an 18-inch telescope allowing it greater sensitivity in low concentration aerosol measurement. This system is not eye-safe.

Laser Induced Fluoresce (LIF) Lidar – Preview the Future

The West Desert Test Center and Space Dynamics Laboratory, a Utah State University Research Foundation, is upgrading the LIF lidar to add an eye-safe wavelength using solid state nonlinear optics technology. The LIF will likely be upgraded by DPG personnel for simultaneous, multi-wavelength measurements of aerosol clouds. The LIF upgrade will allow the system to provide particle size data in addition to its concentration measurement capability.

West Desert Lidar – The two West Desert Lidar (WDL) systems feature scanners capable of ±175° in azimuth and -5° to 45° in elevation with a maximum velocity of 10 degrees/second. Custom-built at the WDTC, the WDL systems are the primary biological referee systems which provide real-time data analysis and plotting and can be viewed within the system as well as at a remote command post. The WDL systems use 14-inch collection telescopes, operate at 1064 nm, have an output average power of 8 watts, and are not eye-safe.

Differential Absorption Lidar – Differential Absorption Lidar (DIAL) lasers transmit long-wavelength infrared (LWIR) pulses (9-11 micron wavelength with average power of 40 watts) into a chemical simulant cloud at two wavelengths, one of which is absorbed by vapor molecules and one that is not absorbed; the difference in the return signals from backscatter on the absorbed and non-absorbed wavelengths is used as a direct measure of the cloud concentration. This system uses an 18-inch collection telescope. This system provides real-time data analysis and plotting which can be viewed within the system as well as at a remote command post location during testing. The DIAL system is still under development and will be used to referee chemical aerosol tests. This system is not eye-safe.

Quick Facts

WDTC lidar systems have supported numerous test programs and organizations, including:

- Joint Biological Standoff Detection System
- Defense Threat Reduction Agency
- Next Generation Chemical Standoff Detection
- Army Sustainment Command

Radar Systems

Division: *Test Engineering and Integration* **Branch**: *Electronics*

Capability Summary

The West Desert Test Center (WDTC) deploys mobile tracking and muzzle velocity radar systems to collect velocity and trajectory data during projectile tests, including small arms, the rail gun, artillery, rockets, mortars, and missiles. Tracking radar systems have also supported the Extended Range Multi-Purpose Platform (ERMP) Unmanned Aircraft System (UAS) tests at Dugway Proving Ground to track and record data from all ground targets and fired missiles within the terrain of the test area.

For information on weather radar systems, see **Meteorological Instrumentation**.

System Description

All radar systems are continuous wave (CW) X-band mobile radar systems manufactured by Weibel Scientific and Raytheon Company. Radar operations are typically managed by a minimum of two certified operators who handle all aspects of the test, including planning, setup, operation, and post-test data processing and analysis.

Prior to the start of a test, the radar system is set up at the test site and the radar and launcher locations are surveyed with a portable GPS unit. The radar is aligned with a boresighted scope to known reference points on the test range. An operator enters the tracking parameters and settings and places the radar into its armed state. A flash detector or fire control signal triggers the radar at the start of the firing or launch; during the test, the operator may adjust beam width and Fast Fourier Transform (FFT) length.

Tracking radar system

Data from the test is collected, stored, and analyzed by the operators and test officer and results reported to the customer. Data products may include: target position, velocity versus time, impact coordinates, spin rates, muzzle velocity, and impact velocity.

Tracking Radar Systems

Tracking Radar System, Analyzer Doppler (RTP-2100) – The Weibel tracking Doppler radar is a 60-watt CW X-band mobile radar system. It is used to collect velocity and trajectory data on a variety of projectiles including small arms, rail gun, artillery, rockets, and missiles. The system can also be used as an X-band threat emitter. Velocity and trajectory data, also known as Time, Space, and Position Information (TSPI), is captured from the active radar track and stored on digital computer files for post-mission processing. The system is capable of displaying event times such as rocket on/off, airburst fuze function, and parts separation. Other on-site post-processed (quick look) field data includes TSPI, and numerous velocity and trajectory plots.

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HAWK Radar

Tracking System, Velocimeter, Hawk (AN/MPQ330) – The 400-watt CW X-band mobile radar systems, manufactured by Raytheon, operates in the 10-10.5 GHz band. The Hawk radar systems are also used to collect velocity and trajectory data on a variety of projectiles and primarily serve as a supplement to the Weibel tracking system. The systems are designed to track and illuminate targets in the azimuth elevation and range rate for the Hawk Missile Battery. Mounted on mobile trailers, TSPI is captured from the active radar track and stored via contractor-supplied analog tape for post-mission processing. Hawk radar on-site capabilities include display of event times, such as rocket on/off, airburst fuze function, and parts separation. Several velocity plots and calculated range plots are available with contractor post-test analysis.

Muzzle Velocity Radar Systems

Muzzle Velocity Radar (SL-520) - The WDTC utilizes Weibel short-range 0.5-watt CW X-band radar systems to collect muzzle velocity data on a variety of projectiles, including small arms, mortars, and artillery. The radar is also used to view parts separation and other phenomena during the initial part of a projectile trajectory. A projectile velocity measurement (PVM) radar head is mounted adjacent to a gun barrel and aimed at the projectile's intended path. An optical sensor activated by the muzzle flash triggers the radar system. The projectile's velocity plots are recorded throughout its visible path and digitally recorded by the PVM's processing unit for post-test processing and analysis.

Muzzle Velocity Radar (W-680) – The Weibel W-680 radar is also used to collect muzzle velocity data on a variety of projectiles and to view parts separation and other phenomena during the initial trajectory. Velocity plots are recorded by the PVM and digitally stored for further post-test processing. The W-680 is primarily used to supplement the SL-520 systems during tests.

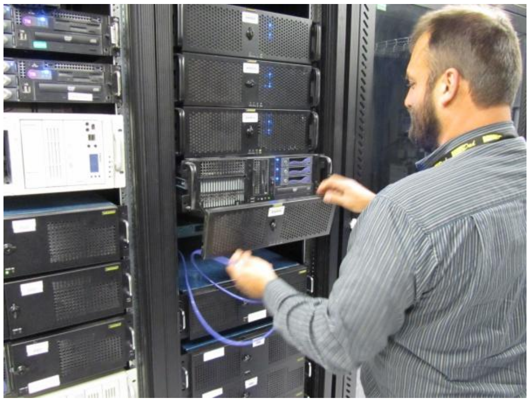
Test Data Acquisition and Management

Division: *Data Sciences* **Branch**: *Test Design and Analysis, System Architecture*

Capability Summary

Information technology is an integral part of the West Desert Test Center's (WDTC) test infrastructure and includes data planning, data acquisition, data analysis services, and system management, as well as programming and software development support. The WDTC network and software systems are continually managed and updated while programmers design, develop, and maintain mission support and data analysis software. Data Sciences Division (DSD) personnel ensure the availability of network information systems, integrity authentication, confidentiality, and system security.

Test Design and Analysis staff ensures efficient and effective test data acquisition and measurements with planning-stage involvement to help define customer requirements and objectives, to strategize how to best meet those objectives, and to establish automated data collection and QA/QC processes for quicker responses. Test data may include: chemical-biological (CB) sample analyses; functionality and response of a system under test (SUT); environmental and meteorological conditions; CB cloud characterization and movement; and permeation/penetration data among many other types of data streams.



The Test Mission Support System (TMSS) is the overarching component of the WDTC information technology system for test data collection, transfer, and storage. The Mobile Image Processing System (MIPS) is a photonics data processing capability that can support multiple field and chamber test programs. The photonics Image Data Processing Lab and secure facility have a complete suite of image processing software and analysis hardware tools and applications, both COTS and custom-developed systems and applications, to provide complete analytical answers supporting SUTs.

Capability Description

Data Sciences manages the WDTC information technology systems, which encompass test support, wireless and fixed networks and systems, data storage and archival, and system security and confidentiality. Information assurance personnel implement and monitor security measures for the TMSS network and ensure that the test network, DPG personnel, and customers adhere to established security standards and governmental requirements for system security.

Programmers design, develop, and maintain mission support software, including: building software tools that support planning and decision making, joint experimentation, and reachback to customers; development of custom software applications, such as a cloud characterization program for the Meteorology Division, data reduction programs, and metadata management software; and publishing documents such as user and training manuals.

Test Design and Analysis

Test Design and Analysis (TDA) statisticians and research analysts support customer tests and experiments at the planning stage by assembling a data team to assist in design of experiments (DoE) and to develop a data collection strategy.

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Before a test program begins, a data team is assembled to meet with the customer and test team to obtain objectives and requirements; the data team provides test project input by identifying questions, assumptions, risks, test constraints, and critical differences, while assisting in determining data streams to be collected (e.g., test item tolerances and units, temperature, relative humidity, wind speed/direction, detector response time, etc.), and associated data collection and referee instrumentation requirements. The statisticians use the input to create test matrices based on statistical concepts and to develop tools for collection and post-test analysis.

The team develops a Data Management Plan (DMP) that includes the test matrix along with instrumentation to be used for data collection. Prior to testing, the team produces a dataflow map to establish projected turnaround time for each step in the process. The team also generates representative data output (e.g., sample analysis examples, tables, graphs, summaries) to review with the customer which allows the customer to approve or make changes to the test program before the test begins. After test data parameters are established, the data team develops automated processes to collect, transfer, store, and archive the test data.

> **Quick Facts**
>
> Advantages of DSD pre-test planning and DoE involvement:
>
> - Knowledge of Dugway equipment, fixtures, and instrumentation capabilities
> - Established relationships with project managers, evaluators, scientists and test officers
> - An efficient and cost-effective test program
> - Automated data collection/analysis processes ensure fast and comprehensive test results
> - Customer involvement allows for changes prior to testing
> - Customer support from Dugway data team

Once the data has been collected, the team merges or reduces the data (including optics, photonics, and instrumentation data) to usable formats and summarizes into reports, assists with data analysis and authentication, archives the data, and prepares customized data packages for the customer. The data team can also prepare Test Incident Reports (TIR) which documents unplanned incidents that may occur during testing.

Test Mission Support System (TMSS)

TMSS is the WDTC network system used to collect, transfer, and store test data. The TMSS core infrastructure consists of a resilient, secure, and intelligent switched network. The Ethernet routing switch core creates a terabit cluster solution offering intelligent Layer 2-7 switching, internal firewall capabilities, up to 768 Gigabit Ethernet ports, and 192 ten-Gigabit Ethernet links providing a foundation for future network growth.

TMSS edge and test grid wired infrastructure consists of stackable Ethernet switches that have resilient high-performance capabilities and include advanced routing, Quality of Service (QoS), convergence, security capabilities over 10/100/1000/10000 Mb/s, and 802.3af Power over Ethernet (PoE). The test grid wireless infrastructure includes seventeen 30-meter Wi-Fi towers and 27 portable 10-meter towers that cover the grid with a wireless network and allows test equipment to connect and operate as a large outdoor laboratory

Optical Data Reduction

Dugway propriety software includes DCTOMS (Dynamic Cloud Target Obscuration Measurement System), 3DCAV (Three-Dimensional Cloud Analysis Visualization), TRACE (Temporally Recognized Automated Cloud Extraction System), Ballistics and TSPI (Time Space Position Information) X-Y+T Process, and OCREP (Optical Character Recognition Extraction Process).

DCTOMS is designed to measure luminescence from recorded video streams and live video feeds in wavelengths between 400 nm and 14 µm, providing obscuration effectiveness and relative transmissivity data. The 3DCAV process provides smoke and obscurant characterization data, reducing recorded video data streams in the same wavelengths, to provide cloud positional and dimensional tracking data. This includes centroid position of the cloud, cloud dimensions, volumetric data and directional information.

TRACE provides 2D polygon image outlines of recognized signatures, such as simulant clouds, that are further processed into a 3D model using the 3DCAV process. The Ballistics and TSPI X-Y+T process can be operated either as a standalone or networked process. It provides multiple X-Y-Z values used in custom image processes, extracting metric analysis data points from various image video streams, both standard (SD) and high (HD) definition formats. Measurements from specific TSPI, single, or multiple events are further correlated with metadata and processed to produce positional information data products.

Other custom software such as OCREP, allows optical character recognition to extract time and event-specific information from live and recorded SD and HD video streams, which can be translated into metric data and information spreadsheets that are further processed using other analytical techniques.

Mobile Image Processing System (MIPS)

MIPS is a mobile image photonics data processing laboratory housed inside a large fifth wheel trailer that can be transported to any location at any time. The system accesses the available WDTC Wi-Fi test area network and WDTC test network access points. By using fiber and copper Ethernet and the Wi-Fi access systems, MIPS can acquire high-resolution photonics data in real time and process post-test recorded photonics data for analysis. MIPS will simultaneously support multiple test programs and record and process large volumes of SD and HD video data streams and optical photonics records.

The system features fast delivery of large data streams of photonics image and data products used to make test scenario decisions. MIPS supports quick-look data delivery and has real-time data presentation capabilities of events being recorded by the optical photonics acquisition systems.

The MIPS trailer features eight HD workstations to support field testing and six major image video processing applications for more detailed analysis. The HD hardware and software provides increased spatial and temporal resolution and an increased resolution target for all recorded optical photonic records to generate and process accurate data products.

The high-resolution analysis processing systems integrated into MIPS enhances WDTC field and chamber test programs for CB point and standoff detectors, smoke and obscurants, explosives, artillery/mortar fired tests, and ballistics. MIPS can support any CB program that requires vapor or aerosol cloud characterization and cloud plume dimensional and positional information. The system provides chamber and field standoff detection-related optical record and photonics applications that require real-time quick-look with post-test standard- and high-definition data processing analysis.

MIPS has been deployed to field trials for toxic industrial chemical (TIC) testing, the Stryker initial operation test and evaluation (IOT&E), and smoke and obscurant testing, among others. Test officers have delivered requested data products to the customer within 24 hours of a test event.

Test Event Imaging

Division: *Test Engineering & Integration* **Branch**: *Test Data Imaging*

Capability Summary

The West Desert Test Center (WDTC) complements its test data acquisition and analytical capabilities with state-of-the-art test event imaging, captured within chemical and biological laboratories, custom test chambers, and across the Dugway test grid and ranges.

Test Data Imaging (TDI) Branch photographers, videographers, optical engineers, and technicians produce full "in-house" test documentary services ranging from high-definition (HD) and standard-definition (SD) photography/videography to full-scale, scripted multimedia productions. Light Detection and Ranging (LIDAR) systems are deployed during chamber and outdoor field trials as standoff referee instruments to detect, track, and characterize chemical-biological (CB) simulant clouds; the Chemical Cloud Tracking System (CCTS) is a networked system of infrared detectors that track chemical cloud movement and produce concentration maps in real time.

The photographic staff creates test imaging documentation with HD visual imagery data collection, infrared/thermal imaging, and high-speed imaging technologies for: CB test programs, including toxic industrial chemicals (TIC); unmanned aircraft system (UAS) operations; contamination and decontamination materiel survivability; military and civil support training; and developmental and operational tests involving munitions, ballistics, and explosives

West Desert Lidar

(including optical support of IED/HME test programs). Multiple data collection and storage systems ensure test images are available for on-site customer review and post-test processing and analysis.

The branch graphics department produces digitally-enhanced photographs of test events for inclusion in final test reports as well as large-format prints to create poster-size depictions of a customer test, unique capability, and promotional messages. Final test reports and images from completed events are burned onto CD/DVDs with printed labels for delivery to customers.

Capability Description

TDI staff provides planning-stage expertise for test events with cost-effective options for photographic and video equipment that best meet a customer's requirements. Photographic staff assists test officers in selecting the types and number of cameras and camera interface (e.g., cable, fiber optics, or WiFi), test setup requirements, and shooting sequences, which in turn aids the data team with design of experiments (DoE) and overall data collection strategy.

Test officers deploy multiple SD and HD cameras at a variety of angles which may be installed inside a test chamber and operated by remote control, including chemical agent and biosafety level (BSL)-2/BSL-3 facilities. For outdoor field tests, cameras may be set up at ground level, attached to fixed or portable towers, or mounted on top of tracking systems. Small, super wide-angle video cameras, like the GoPro® HD Hero®, can be mounted onto the front of vehicles such as an ATV or HMMWV. In addition to SD/HD still and video cameras, data imaging professionals operate digital video recorders, thermal and infrared imaging systems, high-speed digital imaging systems, Moog QuickSet® pan and tilt tracking systems, and related optical systems.

Optical data collection during field tests may include imaging of dissemination or releases of CB simulants, such as methyl salicylate (MeS), triethyl phosphate (TEP), *Bacillus thuringiensis* (Bt), Indium oxide, chlorine or other TICs. Liquid, vapor, aerosol, and powder simulants are disseminated by agricultural spray systems, disseminator stacks, blowers, and explosives. An array of high-speed, HD/SD, and infrared video cameras record initial release and downwind transport of each simulant cloud. Three-dimensional cloud analysis visualization (3DCAV) data is obtained using a wide variety of imaging systems to collect optical data, which in turn provides the basic data to calculate the dimensions of the outlying edges of a visible cloud. Tracker orientation recorded data is added to the video during post-test processing of cloud plume dimensional and positional information.

Camera placement on the test grids can range from several feet to several miles from a test event. Fiber optics allows for remote camera control up to 1.25 miles from the control center, or up to five miles using the grid WiFi system; WiFi repeaters can extend camera operational range up to 30 miles. Eleven, 16-foot mobile trailers provide transport and storage of equipment to any location on the test grid or for safari tests; four trailers are equipped with optical data collection systems, and stable, clean power generators with CyberPower UPS backup systems, for on-site data collection.

Digital video recorders (DVR), such as the Datavideo DN-400 recorder/player, provide high quality HD/SD digital video collection that is stored and later converted to other usable formats, such as Audio Video Interleave (AVI), Windows® Media Video (WMV), or QuickTime® and then archived during post-test processing. DVRs convert raw video data to an AVI format either in the field to allow customers a "quick look" data review or stored for later data analysis. Redundant optical data collection systems, including laptop hard drives, solid-state memory cards, and high-resolution videocassette recorders (VCR) are employed to prevent loss of test data.

Local image storage space is capable of handling large real-time data sets of HD video that is processed from multiple imaging systems. HD storage is available and accessible by using WDTC standalone systems and storage capabilities for large volumes of recorded data products.

All optical data recorded onto SD recording systems incorporate GPS timing information which can be displayed as local, Coordinated Universal Time (UTC), or GPS satellite time. All high-speed camera systems have the ability to integrate GPS time. In addition, local time and UTC may also be encoded onto video recordings. Inter-range instrumentation group (IRIG) time codes may be displayed on SD video.

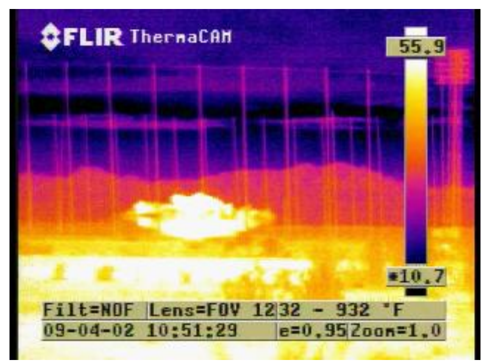
Test Imaging Equipment

Any event occurring in the WDTC can be recorded with a vast array of HD and SD photographic and video equipment that will meet a customer's requirements under all testing, lighting, and temperature conditions. High intensity lighting is available for high-speed events that are not self-illuminating. The following is a brief summary of some of the optical capabilities that are used in WDTC tests. See **Light Detection and Ranging (LIDAR)** and **Chemical Cloud Tracking Systems (CCTS)** for additional information.

High Definition Imaging – The majority of test events are captured on HD still and video cameras to record minute details of a system under test (SUT). Photographers use a

variety of professional Nikon still camera systems, ranging from the most advanced Nikon® D3X to the Nikon® "workhorse" D700. The Nikon® D3X D-SLR features 24.5-megapixel FX-format (35.9 x 24.0 mm) CMOS sensor and allows for continuous shooting up to 5 frames per second (fps) in full resolution. Photographers have available a wide selection of interchangeable lenses ranging from ultra wide angle (10-24 mm) to ultra telephoto (≤600 mm), with the capability to extend the telephoto range beyond 600 mm. For video recordings, the Sony® HXR-MC50U AVCHD camcorder features a wide-angle Sony® G lens, single ½.88" Exmor™ R sensor with 6 million pixels (low-light sensitivity), adaptive MPEG-4 codec, full-raster 1920 x 1080i HVCHD high definition recording capability up to 24 Mbps. The Sony® HXR-MC50U has a built-in 64 GB solid state hard disc drive to store up to six hours of HD video footage in FX mode. This model also has an infrared illuminator that allows nighttime imaging under low light conditions and built-in GPS.

High-Speed Imaging – WDTC tests involving explosives, ballistics, or UAS, require ultra high-speed HD digital photography and test officers rely upon a multitude of cameras to document a customer's test from a variety of angles. TDI provides world-class, high-speed HD digital photography using some of the most advanced high-speed digital cameras on the market. High-speed cameras in the branch inventory include the Vision Research Phantom® series of cameras. The Phantom® v711 can shoot a resolution of 1280 x 800 pixels at 7,350 images per second (ips), or up to 1,400,000 ips at reduced resolution. Videographers may also us the Phantom® v710 and Phantom® V7.3 for high-speed test events. TDI also uses a pair of Photron USA Fastcam APX-RS high-speed cameras which provides 1024 x 1024 at full-frame resolution of 3,000 ips. The camera's control interface is via fiber optics which provides secure data transmissions up to 1.25 miles. Slow-motion replays of test event footage allow customers to view the sequence of events.



Thermal image of explosives test at Tower Grid

Infrared and Thermal Imaging – Infrared cameras detect radiation emitted by an object to produce thermal images of various WDTC tests, including temperature measurements, detection of CB simulant or TIC clouds, explosives testing, and ballistics tracking. The FLIR® Systems, Inc. SC7900-VL incorporates a high quantum efficiency (QE) 320 x 256 element and mercury cadmium telluride (MCT) infrared focal plane array with spectral response from 7.7 to 11.5 µm and temperature calibration range of -20°C to 1500°C. The FLIR® Orion SC7000 features a rotating filter wheel with 8 filters allowing instantaneous imaging of sub-spectral bands and visually shows heat and temperature changes; spectral response is 1.5 to 5 µm or 7.7 to 11.5 µm.

Orion IR camera

The portable FLIR® SC2000 infrared camera incorporates a high QE 320 x 256 element with a thermoelectric-cooled, MTC infrared focal plane, and a spectral response from 800 nm to 2.5 µm. The computer-controlled FLIR® Thermacam® SC500 thermal infrared camera features microbolometer detector technology with 7.5 to 13 µm imaging and can distinguish 0.1°C temperature changes across temperatures ranging from -40° to 2000°C

Closed Circuit Television (CCTV) – Commercial off-the-shelf surveillance cameras may be set up on the test grid, inside a building, or inside a test facility. High-resolution CCTV cameras with variable zoom lenses record indoor test events under closed conditions. Remote-controlled surveillance cameras and HD multi-channel recorders capture a test event at 10 Hz video rate for each video stream, which are encoded with numeric and bar code time stamps.

Multimedia Productions

Dugway's photographic/video capabilities expand beyond the realm of documenting test events with the ability to create broadcast quality multimedia productions. While test documentation "captures an event", video productions "tell a story" which may be scripted or non-scripted. TDI staff has produced a variety of training videos using Dugway facilities and resources in support of Special Programs Division courses, police crisis response, and firefighting techniques.

Scene from an emergency response training video filmed at Dugway

By working with a customer in the planning stages, a producer takes a customer's idea, gains an understanding of the intended scope and rationale, then shapes the concept to become a final production using multiple audiovisual formats, including standard speed, high-speed, HD, and still images. Electronic news gathering (ENG) video cameras with interchangeable lenses allow scenes to be captured with the same quality as produced in television studios.

A time line and script may be developed with video shooting sequences established in chronological order as many scenes cannot be replicated. A multimedia production may range from edited clips with music background, to full scripted video segments, complete with actors, music, professional narration, titles, and sound effects.

Dugway's sound-proof audio studio allows for recording of narrations and synchronization to video footage. A large number of sound effects options and music tracks augment a video production.

An Avid Media Composer (Avid Technology, Inc.) is a non-linear editing system (NLE) that allows for film editing, uncompressed standard definition video, and high definition editing and finishing. Post-production editors can take long-term (24-hour) video recordings and convert them to time-lapse video, or compress several hours of footage into several minutes of finished video. Film can be digitized, edited and modified to slow down, speed up, or synchronized with other media formats. TDI deploys a fully-equipped mobile unit to anywhere on the Dugway test range or on safari test events.

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Graphic Artwork

TDI graphic designers prepare technical illustrations for reports and publications, drawings, charts, posters, visual displays, and marketing materials for internal and external customers. Labeled CDs and DVDs of final test reports and other test documents are produced by graphics personnel. Photographic enhancement or improvements can be made to both digital and film prints, including scanning of archival photos and touching them up for use in formal presentations.

Large format prints up to 44 x 90 inches and be produced on an Epson Stylus® Pro 9800, which utilizes Epson UltraChrome K3® ink technology featuring eight color pigments and three-level black ink technology (black, light black, and light, light black inks) to produce true monochrome prints. An Epson Stylus® Pro 7890 incorporates the same ink technology with a maximum resolution of 2880 x 1440 dpi for prints up to 24 inches wide. The printers are compatible with most media types, including photo paper, vinyl for backlit signage, canvas, perforated vinyl/perforated film, and up to 1.5 mm thick posterboard. A 60-inch lamination system provides protection for large prints.

Finishing work includes mounting prints on foamcore, single matboard, or Gatorboard®, and framing. In addition to mat cutting, technicians can cut glass, Masonite board, and lightweight metals.

Quick Facts
A recent field test program involving an explosive release of simulant used an array of high-speed (4), HD (4), and SD (4) cameras placed a various distances in a ring around ground zero. The test generated a half-terabyte of image data.

West Desert Technical Information Center

A U.S. Army technical library supporting the Dugway mission, The West Desert Technical Information Center (WDTIC), provides excellence in scientific and technical information services to the Dugway workforce and to the U.S. chemical-biological (CB) defense community. The WDTIC houses approximately 65,000 classified and unclassified documents dating back to the 1940s, including rare and irreproducible documents from the era prior to the U.S. ban on open-air, live-agent testing.

The WDTIC's unique collections consist of documents from: Deseret Test Center, Fort Douglas, UT; Dugway Proving Ground/West Desert Test Center; Fort Detrick, Frederick, MD; Tropic Test Center, Panama; and Chemical Weapons Convention.

The WDTIC staff works closely with the Chemical, Biological, Radiological and Nuclear Defense Information and Analysis Center (CBRNIAC), the DoD repository for chemical-biological defense and Homeland Security scientific and technical information. The virtual repository CBRN START (Scientific and Technical Analysis Research Tool), a documents database created by CBRNIAC, encompasses WDTIC cataloging records, and searches performed by the WDTIC staff run against this comprehensive source of information.


Technical library staff assists in customer research

WDTIC services include:

- Maintaining a vast collection of CB documents, such as historical documents, test plans, test reports, test analyses, and methodologies.
- Providing access to current and historical document literature through the CBRN START
- Reponses to inquiries from the CB community
- Access to current and historic CB journals and gray literature
- Mediated literature searches
- Dissemination of classified (SIPRNet)/unclassified documents to authorized personnel on and off post.
- Responses to Freedom of Information Act (FOIA) and Congressional requests

The WDTIC prides itself on providing Dugway workforce members and U.S. CB defense community, military, and government customers with prompt responses to inquiries and searches, often producing the desired results within an hour for routine requests, and up to two days for the most complex requests. The staff also maintains a series of searchable databases, and electronic journals, books, and subscriptions to electronic professional publications. Interlibrary loan services provide access to journal articles and books not available locally. Daily and monthly e-mail notices of news of interest to the CB community are distributed to the Dugway workforce. Instructions on how to access the WDTIC collections from an off-post duty station is available.

The WDTIC collection of books and documents includes: CB defense documents collected from government agencies and contractors from around the world; historical reports documenting chemical-biological testing programs; CB Technical Data Source Book (22 volumes) from the Joint/CINC Operational Testing (Project O49) that conducted non-developmental CB testing on land, in the air, and at sea, and covers topics such as CB agents, simulants, modeling, and decontamination; and documents and reports from CB tests conducted in the tropics, including degrading environmental factors, materiel degradation, and vehicular testing.

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Section 8

Meteorology

Weather Forecast Systems

Division: *Meteorology* **Branch:** *Meteorology Operations*

Capability Summary

Meteorologists at Dugway Proving Ground (DPG) who support research, development, testing, and evaluation (RDT&E) programs provide vital weather modeling and measurements which directly influence test item performance and the ability to quantify a test item's weather dependencies and vulnerabilities.

Accurate weather forecasts and downwind hazard modeling support the West Desert Test Center's (WDTC) outdoor field testing and research programs – evaluation of chemical-biological (CB) detector systems, CB simulant challenges of individual and collective protection equipment, determination of smoke and obscurants effects, and unmanned aircraft system (UAS) tests – allowing test officers to make informed decisions whether to proceed or to postpone a test.

WDTC Meteorology Division employs a large suite of systems and instrumentation designed to observe and predict weather conditions over the entire test range. In particular, three state-of-the-art technologies – the Four-Dimensional Weather (4DWX) System, the High Performance Computer (HPC), which produces the Ensemble-Four-Dimensional Weather System (E-4DWX), and Weather Surveillance Doppler Radars—combined with other meteorological instrumentation produce the best weather picture for test officers and researchers.

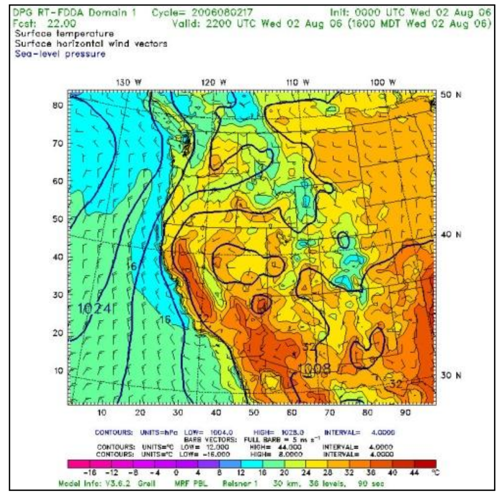
System Descriptions

Four-Dimensional Weather (4DWX) System

The Army Test and Evaluation Command's (ATEC) weather system was developed by the Meteorology Division at DPG and the National Center for Atmospheric Research (NCAR). The Four-Dimensional Weather (4DWX) System provides high-resolution weather forecasts and analyses to support developmental and operational field tests in a three-dimensional structure of the atmosphere over time (4th dimension).

The 4DWX provides a single data archival/retrieval system for all range and external meteorological data, and a high-resolution, weather model with a globally relocatable capability. It has user-configurable displays, web access, coupled range applications models (e.g., dispersion, noise propagation, etc.) and an automated thunderstorm forecast system.

The two central modeling technologies of 4DWX are the Real-Time Four-Dimensional Data Assimilation (RT-FDDA) and the weather forecast model. The RT-FDDA scheme assimilates into 4DWX a wide range of weather observations from commonly available and specialized sources such as National Weather Service (NWS) standard upper-air and surface reports, wind profilers, satellite cloud-drift winds, commercial aircraft reports, and radar observations.



4DWX surface temperature image

During the analysis stage, the RT-FDDA modifies a previous 4DWX forecast, to nudge the model solution toward observed conditions. The scheme is computationally efficient and preserves the precise timing of observations, which gives 4DWX a more accurate depiction of the weather at any instant.

The second central modeling technology of 4DWX is the community mesoscale weather model, the Weather Research and Forecasting (WRF) model. WRF is a full-physics mesoscale model, with ongoing research and development by hundreds of users worldwide. NCAR adapts successful and well-tested technologies into the WRF implementation used by the 4DWX.

New analyses and multi-day forecasts are computed every three hours on a 1.1 km grid positioned across DPG. Daily land-based and aerial test operations and training can be implemented or adjusted based on current weather data.

The Global Meteorology on Demand (GMOD) capability, a web-based graphical user interface, allows Army test ranges to set up and launch WRF analyses and forecasts from any location in the world. A Linux PC cluster dedicated to GMOD modeling applications also serves as a backup to the range 4DWX modeling systems.

High-Performance Computing

The Meteorology Division runs an operational version of the Mesoscale Model Version 5 (MM5) and WRF models in a 30-member ensemble weather forecast system using a 256-processor Linux cluster high performance computer (HPC). An expanded version of RT-FDDA, which generates ensemble analyses and probabilistic forecasts, is called E-4DWX.

E-4DWX produces 48-hour forecasts every 6 hours for all 30 ensemble members, running with 3.3 km grid spacing. Once the 30 model runs are complete, data generated by customized post-processing algorithms provide a suite of probabilistic forecast products, accessible through the Dugway public website.

As with all ATEC 4DWX systems, the computational grids can be moved to new locations worldwide to meet requirements. Ensemble predictions are providing ATEC meteorologists with an objective basis for quantifying the range of uncertainty in model forecasts and for estimating the probability of occurrence of critical meteorological thresholds.

Surface-based products include: wind roses (predict wind speed and direction), spaghetti plots (wind speed, temperature, precipitation), histograms of wind direction/speed, temperature, precipitation, and planet boundary layer (PBL), Ensemble Prediction System (EPS) grams (wind speed, temperature, humidity, precipitation), frequency of occurrence (wind speed, temperature, precipitation), and mean/standard deviation minimums/maximums (wind direction/speed, temperature, humidity, precipitation, and PBL).

By comparing results from all 30 ensemble members, forecasters can judge the probabilities of occurrence of desired atmospheric conditions, and can assist a test officer in determining favorable locations on a test grid to initiate a test, such as the release of a simulant cloud so the cloud travels over the truth box and encounters as many CB detectors as possible. In addition, information about potential hazardous weather conditions (strong winds, lightning, hail, or snow) allows test officers to take measures to protect personnel and equipment.

When not in use to support operational RDT&E activities, the 4DWX HPC is used by the National Center for Atmospheric Research (NCAR) to develop and test new or enhanced 4DWX mesoscale modeling capabilities.

Weather Surveillance Doppler Radars


C-Band Doppler radar

The West Desert Test Center (WDTC) Meteorology Division has two weather surveillance Doppler radars, fixed-site C-band radar and mobile X-band radar. The radar systems provide meteorologists with the capability of more precise local weather surveillance compared to using NWS radar, located 100 miles from Dugway.

The C-band radar is used for test support and is a valuable tool in identifying the location, type and intensity of precipitation occurring at DPG. The X-band mobile radar allows meteorologists to monitor weather conditions in regions where the C-band radar is blocked by terrain.

Data from the C-Band radar enables implementation of the Variational Doppler Radar Analysis System (VDRAS), and eventually the 4DWX Autonowcaster, which predicts thunderstorm development, intensity, and motion. It is expected that the two radar systems can be used in concert to derive true, three-dimensional wind field retrieval.

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Meteorological Instrumentation

Division: *Meteorology*   **Branch:** *Meteorology Operations*

Capability Summary

The Meteorology Division at Dugway Proving Ground incorporates a comprehensive suite of instrumentation and computational resources to support chemical-biological, obscurant, and Unmanned Aircraft Systems (UAS) test programs. Meteorologists assist in test planning, test execution, and post-test analysis for both outdoor and large chamber test trials.

A network of fixed instrumentation suites, coupled with a broad range of mobile and remote systems utilized throughout the West Desert Test Center (WDTC), provides general and test specific weather forecasts and warnings, routine surface and upper air observations, and *in situ* and remote meteorological sensing.

Additional test support capabilities include:

- Test grid meteorological support infrastructure
- Setup of specialized equipment
- Over 100 meteorological measuring and monitoring sites
- Meteorological and atmospheric dispersion modeling

Instrumentation Descriptions

C-Band Doppler Radar –The fixed-site C-Band Doppler radar, located west of the Life Sciences Test Facility, provides high spatial and temporal resolution of wind and precipitation fields across the WDTC test grids. The radar provides 24/7 surveillance of atmospheric phenomenon, such as strong thunderstorm winds, hail, dust devils, and heavy rain that occurs below the view of the National Weather Service radar located at Promontory Point, UT, from surface to approximately 7000 feet. The system features a Magnetron transmitter which provides a 250 kW peak radio frequency (RF) power pulse with durations of 0.2, 0.4, 1.0, and 2.0 microseconds, and 60 MHz multi-channel digital receiver and signal processor. The parabolic, prime focus reflector antenna has an angle span (azimuth) of 0° to 360° continuous and angle elevation of -2 to +90°; the scanner can operate stopped or up to 6 rpm.

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X-Band Doppler Radar – The X-Band Doppler radar system is mounted on a mobile platform and can be operated nearly anywhere on DPG (or, with permission, on safari) wherever there is an adequate road surface. An on-board generator provides power and air conditioning for the electronic systems. The higher frequency (8500 – 9600 MHz) allows for a more detailed examination of meteorological phenomenon at specific locations across the test range. The Magnetron transmitter generates 200 kW peak RF power pulse with durations of 0.2, 0.4, 1.0, and 2.0 microseconds; the modular, multi-channel digital receiver and signal processor operates at 60 MHz. The parabolic, prime focus reflector antenna features an angle span (azimuth) of 0° to 360° continuous and angle elevation of -2 to +90°; the scanner can operate stopped or up to 6 rpm.

X-band mobile Doppler radar

WindTracer® Doppler LIDAR – A Lockheed-Martin Coherent Technologies WindTracer® Doppler Light Detection and Ranging (LIDAR) system analyzes the transitory nature of extreme low-level wind fields at Dugway. Currently sited at the Meteorology Upper Air Facility to support chemical, biological, and unmanned aircraft system (UAS) tests, WindTracer® data is mapped across the field of view up to a distance of 4 km and is ingested into 4DWX (see **Weather Forecast Systems**) along with other wind measurements to improve local forecasts of winds and to measure turbulence characteristics of the winds along and cross to the runway.

Frequency Modulated Continuous Wave (FM/CW) Boundary Layer Radar – During outdoor field testing, chemical-biological simulants are often released into the atmosphere near ground-level (boundary layer) requiring meteorologists to forecast movement of the released material. The FM/CW radar is a vertically-pointing, S-Band (2.9 GHz) radar that detects the height of the boundary layer in clear air. The radar detects indications of turbulence in clear air providing updates once per minute to test officers and UAS operators. The radar, under certain conditions, can also detect the height of the water ice melting layer. The radar and antenna are mounted on trailers allowing the instrument to be moved to any location on the range with appropriate power, and to any safari location meeting siting requirements.

FM/CW Boundary Layer Radar

924 MHz radar wind profiler system

Radar Wind Profilers – Dugway utilizes two 924 MHz radar wind profilers and one 449 MHz radar wind profiler to measure the vertical profile of horizontal wind speed and direction, and vertical wind velocity, at greater than three kilometers (924 MHz) or greater than eight kilometers (449 MHz) above ground level. The 924 MHz profilers are relocatable and can operate at sites with sufficient power; the 449 MHz profiler antenna is attached to a fixed platform at Horizontal Grid. The profilers also incorporate the Radio Acoustic Sounding Systems (RASS) to measure the vertical profile of virtual temperature up to 1.5-km above ground level. The systems operate unattended and provide continuous, real-time atmospheric wind and virtual temperature data with excellent temporal resolution.

Surface Atmospheric Measurement System (SAMS)

Surface Atmospheric Measurement System (SAMS) – A standard World Meteorological Organization (WMO)-type automated remote weather station that measures: wind direction and speed (2 and 10 m), air temperature, relative humidity, barometric pressure, liquid accumulated precipitation, solar radiation, soil temperature (4 levels), soil moisture (2 levels), and skin temperature. A subset of SAMS stations measure net radiation (longwave and shortwave), snow depth, and dew formation. Data are collected at one-second intervals with five-minute averages transmitted to the Meteorology Center via spread spectrum radio. All stations (31) are solar powered and are strategically placed throughout the test range. The network is planned to be expanded to 35 stations in the near future.

Portable Weather Instrumentation Data System (PWIDS) – The Meteorology Division developed PWIDS to record standard meteorological measurements at the 2 m height, to communicate with the Meteorology Center and to record and display data. PWIDS data are provided to test officers located at test range command posts. The 113 PWIDS stations measure wind speed, wind direction, temperature, relative humidity, and barometric pressure; approximately half of the stations are outfitted with solar radiation sensors. Data are collected at one-second intervals and 10-second averages are transmitted to the Meteorological Center for display, storage, and analysis. Each PWIDS station has a single data logger with spread spectrum real-time data transmission. PWIDS have been deployed on a variety of "safari" tests to support urban test programs.

Portable Weather Instrumentation Data System (PWIDS)

Mini-SAMS – The Dugway Meteorology Division created a microscale *in situ* meteorological sensing system called mini-SAMS, which is a blend of SAMS and PWIDS equipment and telemetry techniques. The network significantly improves the fine-scale measurement of basic meteorological parameters across the Target-S and Downwind test grids. The 51 mini-SAMS stations provide WMO-type automated remote weather measurements, including wind direction and speed (at 2 and 10 m), air temperature (2 and 10 m), relative humidity (2 and 10 m0, and barometric pressure (2 m). An additional 20 mini-SAMS stations are scheduled to be installed primarily around Granite and Camelback mountains in 2012.

Sonic Anemometer

Sonic Anemometers – Atmospheric turbulent properties can be measured utilizing three-dimensional sonic anemometers independently, as part of "Sonic PWIDS," or attached to various meteorological towers. The (60+) anemometers measure 3-D wind direction and virtual temperatures (or speed of sound) at a rate of up to 10 times per second (10 Hz). Data are either stored on local data loggers or transmitted in real-time to a command post or the Meteorology Center. Instruments can be deployed within WDTC test facilities, such as the Joint Ambient Breeze Tunnel, or in cities such as downtown Oklahoma City where a major urban experiment was conducted in 2003.

Solar-powered miniSODAR™

Sonic Detection and Ranging (SODAR) – Four Doppler acoustic sounding systems (three miniSODAR™ systems and one Scintec instrument) are capable of making fine-scale measurements of vertical profiles of horizontal wind speed and direction below the levels of radar wind profilers. SODARs record measurements in specified increments (e.g., 10 m) from below the tops of 32-meter towers to approximately 200 meters above ground level. The systems operate on solar power and may be transported to any location on the test and training range.

Electric Field Meter Sensors – A network of 39 field-meter stations provides meteorologists with a spatial and temporal view of the vertical component of the earth's electric field across the test and training range. High magnitude fields are often associated with imminent lightning strikes. The field meter network will be expanded to 49 stations in 2012 making it the largest network of its kind in the United States.

Lightning detection array

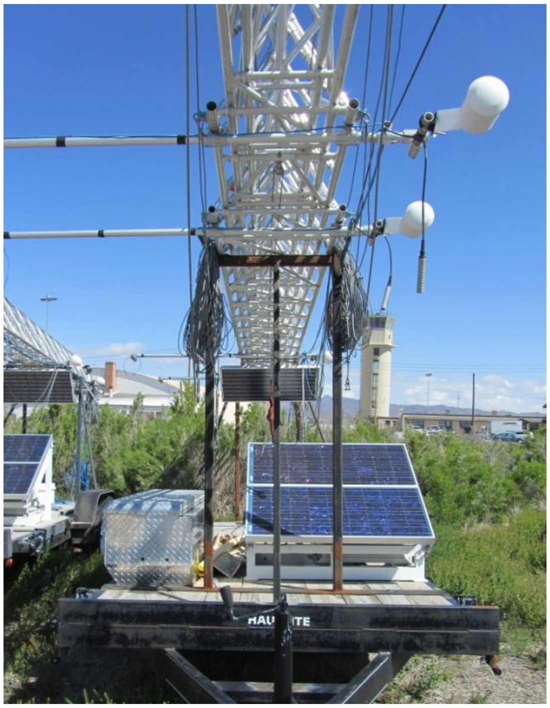
Lightning Mapping Array – A 12-station lightning mapping array, a network of receivers and processing equipment, maps each small piece of a lightning flash, including in-cloud lightning. The data obtained provides meteorologists with additional lead time to determine if lightning-containing clouds and thunderstorms could impact Dugway test operations.

Upper Air Sounding System – Three Vaisala DigiCORA III upper air sounding systems can be operated from a facility at the Ditto Technical Center or nearly anywhere on the test range. The systems consist of balloon-borne transmitters that report temperature, relative humidity, and pressure, with a GPS-based positioning system that provides wind speed and direction information. Typically, the upper air stations provide atmospheric information from surface to over 100,000 feet. The *in situ* radiosonde collects data every two- to three seconds from the time of launch and for the length of time the weather balloon remains intact.

12,000-foot Ceilometer

Upper-Air Tethered Sounding System – The Meteorology Division employs two tethered weather balloons to record fast, highly-accurate measurements of wind speed and direction, relative humidity, and temperature at either specified elevations or within the lowest three kilometers of the atmosphere. The instruments record measurements approximately every three seconds and transmit the data to existing upper air stations.

Ceilometers and Sky Imagers – Meteorologists can obtain precise measurements of clouds and cloud coverage – vital to short-term forecasting of winds, temperatures, and precipitation at Dugway – with four cloud-height ceilometers and two whole-sky imagers. Ceilometers measure the height of the base of clouds over the observed site; calculations using the integration of cloud motion over time provide a proxy for cloud cover. Whole sky imagers perform an accurate assessment of the sky's cloud cover both day and night. Together, the two systems provide meteorologists with a high-quality, automatic, continuous view of sky conditions.



32-meter mobile tower

32-Meter Towers – Three 32-meter fixed towers (with three more planned) and seven 32-meter mobile towers are available for test support and climatological monitoring. The fixed towers will be equipped with sonic anemometers and the mobile towers can be equipped with either standard meteorological sensors or high-speed sonic anemometers for turbulence monitoring at heights up to 32 meters above ground level. Measurements at all stations can include up to five levels of wind direction, wind speed, air temperature, and relative humidity. Barometric pressure is measured near the base of the tower and all data are transferred via spread-spectrum transceivers.

Specialized Meteorological Instrumentation – The Meteorology Division supports a broad range of customers both at Dugway and off site (safari) with a supply of specialized instrumentation to provide meteorological data in almost any environment. The specialized instrumentation and quantity includes:

- 3-Bowen ratio stations
- 4-Energy balance stations
- 8-Quartz thermometers
- 11-Present weather stations
- 1-Hot plate precipitation gauge for detecting very light precipitation
- 1-Precision temperature and dew point sensor
- 2-Scintillometers
- 100-Photoionization detectors
- Transmissometers
- UV sensors
- Precision visible and infrared pyranometers

Surface Layer Turbulence and Environmental Science Test (SL-TEST) Facility – SL-TEST is used for large Reynolds number fluid dynamics experiments and support of atmospheric and biosphere sensing studies. Experiments conducted at the site include flow around obstacles, surface stress, large scale flow visualization, dispersion and deposition, atmospheric chemistry, and surface energy balance studies. The facility includes a near-surface turbulence measurement platform (NSTMP), electrical power outlets, lighting, trailer parking, and communications lines (telephone and network). The facility and its equipment were designed for cooperative studies serving the needs of the government, academic communities, and private industry.

3-D sonic anemometer supported the Joint Urban 2003 Experiment in Oklahoma City

Targeted Meteorological Instrumentation Capabilities – Most instruments and instrumentation systems may be transported to any location on the test range or on safari. In previous tests, the meteorological sensing assets have been used at other test ranges (e.g., White Sands Missile Range), other military sites (e.g., Pentagon), and civilian locations (e.g., Oklahoma City). The Meteorology Division also has an inventory of reserve and spare parts to either rapidly repair faulty equipment or to create new, specialized instrumentation suites for use in specific test programs. For example, new thermocouple probes were quickly assembled and deployed for the Jack Rabbit test in the spring of 2010.

Atmospheric Transport and Dispersion Modeling

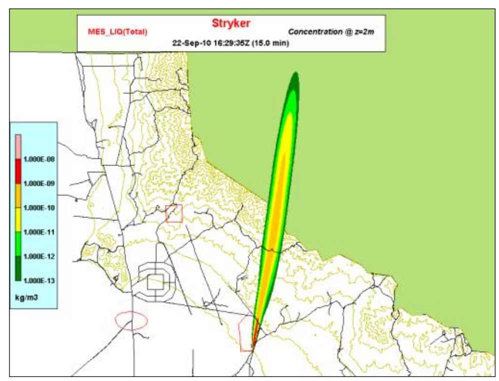
Division: *Meteorology* **Branch:** *Modeling and Assessment*

Capability Summary

Atmospheric Transport and Dispersion Models (ATD) at the West Desert Test Center (WDTC) support test programs through accurate predictions of actual or simulated chemical-biological (CB) agent or simulant releases, including tracking movement, concentration, and the effects of weather and complex terrain. In addition, data from ATD models can be automatically communicated to an emergency response system allowing responders to plan response operations and actions such as establishing evacuation routes, shelters, and relocation areas.

Dugway Proving Ground (DPG) meteorologists test, evaluate, and validate new numerical weather prediction and ATD models related to CB defense, and adapt new theoretical and empirical developments to meteorological modeling and forecasting. WDTC scientists organize and participate in national and international CB data collection experiments and tests, while providing independent verification and validation of meteorological and CB defense ATD models.

The Meteorology Division has provided technical management support for the Defense Threat Reduction Agency (DTRA) chemical, biological, radiological, nuclear and high-explosive (CBRNE) hazard assessment technology development program to incorporate weather intelligence into threat assessments, and the Joint Science and Technology Office (JSTO) Sensor Data Fusion Program which blended CB sensor data with dispersion models.



Model Descriptions

Hazard Prediction and Assessment Capability (HPAC)

Hazard Prediction and Assessment Capability (HPAC) model is designed to accurately predict the effects of CB releases into the atmosphere and the impact on military and civilian populations. HPAC software, which incorporates the Second-order Closure Integrated Puff (SCIPUFF) transport and dispersion model, is used to support various field and chamber tests by conducting both pre- and post-test threat simulations.

HPAC is a validated threat modeling program developed by DTRA which uses integrated source terms, high-resolution, real-time weather forecasts, and particulate transport to model hazard areas. The HPAC system also has embedded climatology or historical weather data that may be used to plan incidents beyond the normal time associated with credible weather forecast data.

HPAC model simulations provide valuable data to the test community indicating probable hazard trajectory, what downrange concentrations to expect, and where to place referee instrumentation. Additionally, HPAC simulations help fill data gaps by modeling tests that cannot be conducted due to costs, schedules, or environmental regulations.

HPAC utilizes multiple meteorological datasets in its transport and dispersion. These datasets are created by the Meteorology Division which provides real-time cloud projections just prior to and during a plume release to assist with test safety and execution. HPAC has also been used as a research tool in comparing sampler detection with HPAC output as well as determining overall cloud dimensions based on a concentration threshold.

XPAC

XPAC is an interface tool, custom-built by the Meteorology Division, which enhances HPAC's functionality. WDTC field test trials often involve numerous, simultaneous simulant releases where cloud trajectory and dispersion must be continuously updated in real-time. XPAC users can quickly consolidate and update data from all releases simultaneously in real-time, which otherwise would require individual updates. The tool has saved test programs thousands of dollars in labor costs over individual updates using HAPC alone, which could not be accomplished in real time.

Joint Effects Model (JEM)

The Joint Effects Model (JEM), a web-based software application, provides the DoD with the only accredited tool to effectively model and simulate the effects of CBRN weapon strikes and incidents. JEM applications are similar to HPAC in that some simulation exercises are common to both, with HPAC serving as an internal validation for JEM.

The JEM predicts downwind hazard areas and effects associated with the release of CBRN and toxic industrial chemicals/toxic industrial materials (TIC/TIM) into the environment, incorporating the impacts of weather, terrain, and material interactions into the downwind prediction. The model enhances situational awareness of the battle space and provides real-time hazard information to minimize CBRN effects on current operations, including:

- CB weapons and facilities strikes
- Nuclear weapons detonations and incidents
- Nuclear reactor facility releases
- Radiological dispersions
- Stored chemical weapons incidents
- CB high altitude release

JEM interfaces and provides high-fidelity hazard predictions for Joint Warning and Reporting Network (JWARN), and interoperates with current and future meteorological data systems, including DTRA's meteorological data server (MDS) and the Air Force Weather Agency, plus various intelligence systems, and various databases.

WebPuff

WebPuff is a distributed system that aids in the planning, response, and recovery from an outdoor chemical release. Currently, WebPuff is used by meteorologists to generate downwind hazard plots and distances in the event of a chemical incident. The system models a chemical release using Geographic Information System (GIS) technology to assess the risk to surrounding areas and delivers protection action recommendations to emergency responders.

WebPuff utilizes 31 permanent surface weather stations that are placed throughout the DPG test range to calculate a plume's movement. The system also provides a real-time hazard analysis of the plume concentration, peak concentration, dosage, and the population affected. WebPuff is also used for all convoy movements to calculate the downwind hazards of the movement. The software has advanced features which could aid in the communication between a forward operations center and an emergency operations center.

Section 9

Specialized Test and Training

Facilities and Programs

Expansive terrain for tests and training at Dugway Proving Ground

Specialized Test and Training Facilities/Programs

Division: *Special Programs* **Branch:** *Test Management, Operations and Training, Project Science Management*

Chemical-biological (CB) acquisition defense test and evaluation (T&E) programs have long been the staple of business conducted at the West Desert Test Center (WDTC). However, a growing segment of capabilities has evolved in the form of specialized test and training programs in support of the Department of Defense (DoD), Department of Homeland Security (DHS), National Guard Civil Support Teams, U.S. Navy Explosive Ordnance Disposal, and Special Operations Command (SOCOM), among others.

The Special Programs Division (SPD) blends its unique staff of PhD-level chemists, microbiologists, engineers, and operators from the chemical-biological-explosives (CBE) community with Dugway Proving Ground's (DPG) desert and mountainous terrain, plus real-world facilities, to plan and execute tests for: non-acquisition CB defense T&E, non-CB acquisition T&E, and any other type of non-acquisition T&E. In addition, SPD conducts:

- Advanced CBE training
- Tactics, techniques, and procedures development (TTP)
- Operational tests
- Advanced concept technology demonstrations (ACTD)
- Advanced technology demonstrations (ATD)
- Joint concept technology demonstration (JCTD) T&E
- Reachback to SOCOM

Hands-on chemical training program

SPD personnel undergo extensive cross-training with a focus on the customer as the end-user, thus providing the expertise to function as both test officers and training subject matter experts (SME). Results or lessons learned from a specific test can be applied to training programs, sometimes by the following week. This "test-train" cycle in turn may elicit additional questions that can initiate additional tests, and again applied to training programs.

Test Capabilities

The array of SPD capabilities has evolved from supporting SOCOM in advanced chemical and biological sampling, detection, decontamination, production, and defeat testing, to encompass toxic industrial chemicals (TIC), homemade explosives/improvised explosive devices (HME/IED), foreign materiel exploitation, and emerging threat and unmanned aerial technologies. For any test program, SPD provides management and support personnel, test planning and scenario development, test locations and facilities, materials, instrumentation for data collection and meteorological conditions, and still/video documentation to meet customer requirements

HME devices are a constant threat to military forces conducting operations overseas. DPG features expansive terrain similar to Middle Eastern countries allowing SPD test officers to create and implement test scenarios to characterize HME devices and analyze the impact on equipment and vehicles that are similar to those experienced by warfighters.

HME explosives test

An HME test may include explosives formation by certified explosives handlers, characterization of soil conditions, blast effects, device repeatability and variability, and initiation methodology. Post-test analysis may include crater characteristics, impulse energy, and impact on test items, including velocity, height, impulse energy, displacement, and deformation. SPD has created theater-specific HME training targets, including replication of HME labs found OCONUS designed to be as authentic as possible.

Launched unmanned aircraft system

SPD supports Unmanned Aircraft System (UAS) test programs, including development of test programs and providing equipment, applicable training, range scheduling, safety procedures, durable goods, test network, and support personnel. UAS test programs have included aerial assessments of simulated WMD facilities and mobile targets, and the interception and identification of clouds of simulated chemical, biological, radiological, and nuclear (CBRN) materials. SPD continues to provide testing scenarios for next-generation UAS.

SPD conducts developmental and operational system integration testing and data collection for the Joint Land Attack Cruise Missile Defense Elevated Netted Sensor System (JLENS) program. The scope of activities include: establishing test and training facilities, structures, and support sites; identifying test locations for JLENS orbit; staffing support unit locations (e.g., interceptor sites, target launch sites, target storage facilities); and provide personnel to tether, secure, and operate JLENS aerostats.

Training Capabilities

A partner in the global war on terror, Dugway accommodates training of active and reserve military units, National Guard maneuver training, and civilian emergency responders to operate in a CBE warfare or contaminated environment. Dugway's ranges allow for asymmetric and conventional warfare training, including: air/ground deployment of a unit; desert warfare and live-fire ranges; land navigation and off-road vehicle mobility; jump zones and close air support ranges; high-angle marksmanship facilities; IED immediate response drills; and full SOF mission training profiles.

SPD conducts challenging classroom, laboratory, and full-scale field exercises. Subject matter experts can support validation of a response organization's TTP to a simulated chemical, biological, or HME threat or attack. The staff specializes in CBE detection, identification and signature recognition, chemical synthesis, biological fermentation, sampling, hazard mitigation, threat/hazard assessments, personal protective equipment (PPE), decontamination, and field exercises. Classroom lectures, laboratory exercises, and field training can be modified to meet customer needs, or the training staff can develop new courses to meet ever-changing global threats.

Programs for emergency management and first-responders – police, firefighters, emergency medical technicians (EMT), and hazardous materials technicians – provide extensive hands-on experience with CBE in laboratories, detection equipment, and decontamination processes.

Field exercises provide customers with realistic and challenging scenarios featuring role players and targets simulating CONUS and OCONUS environments. Each event is supervised by a PhD-level SME who gives students immediate feedback during field training, in addition to interim after-action reviews and formal after-action reviews. Events can be captured on video and given to students, serving as a resource to retain the vast amount of information presented.

Mobile Training Teams (MTT) can deliver on-site support to any customer's home location. MTTs are flexible in format and are molded to meet the unit's objectives. Courses normally consist of instruction in chemical, HME, and biological material, and complex field events in the unit's area of operations.

Realistic and challenging training exercises

GWOT at Granite Test Complex

Special Programs Test and Training Facilities

The WDTC features a plethora of facilities consisting of classroom buildings, laboratories, real-world test beds, and other sites to accommodate CBE defense and provide realistic field exercises.

Training Building Complex – Located in the Ditto area, the training complex consists of:

- Biological Defense Mission Support Facility
- Chemical Defense Mission Support Facility
- Chemical Detector Laboratory
- Advanced Detector/Decontamination Lab
- BSL-2 Lab
- Biological Signature Lab

Granite Test Complex is located approximately 25 miles west of Ditto and is used primarily for operational testing and TTP development, plus combat services support operations. The Global War on Terrorism Facility (GWOT) provides Army units a crude OCONUS facility. Within the 200'x200' fenced area are four buildings connected by five-foot tunnels, reinforced barriers, breaching walls of various construction, obstacles, and a rogue laboratory. The GWOT is used for operational and TTP development and is authorized for dissemination of CB simulants. Granite Tunnel, located on the northeast side of Granite Mountain, is a 16'x16'x150' tunnel with a 30'x70'x18' alcove and ventilation shaft, and is used to replicate CBE threat scenarios. The Georgia facility, located west of Granite Mountain, is a 250'x300' compound of six buildings, including a full-scale biological training and testing facility for biological production, isolation facility, classroom, and sleeping bay for 20 personnel.

Training tunnel inside GWOT

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Wig Mountain Test Complex provides a CB defense arena for civilian and military personnel. The complex includes: a large biological test facility; an 8,800-square-foot chemical production facility with production lab and control room; and a two-story housing duplex with garage and basement designed to simulate residential environments and used to demonstrate clandestine laboratory manufacturing techniques for CB weapons.

Simulated production lab at Mustang Village

Mustang Village Urban Test Complex, located adjacent to Wig Mountain, is designed to reflect the architecture, construction, and materials of common structures in a real-world environment. Buildings include a motel, post office, warehouse with a high-fidelity biological production capability, strip mall with a simulated deli, diner and bar, office building, and administration building.

Mustang Village is used for:

- Urban operational chemical/biological testing and TTP development
- Combat maneuvers (simulated fire)
- Remote terrorist encampments
- Urban WMD even simulation
- Location to simulate escape and evasion scenarios

Mustang Village buildings house small-scale CBE production laboratories or facilities where chemical-biological simulants can be released to test a customer's tactics, techniques, and procedures. Camera systems at target locations can record activities for after-action reviews. A separate two-story duplex includes an intermediate-scale chemical test and TTP development facility.

Avery Tunnel is a four-foot wide, 750-foot concrete facility (approximately 6 feet high), located 20 feet underground, and simulates a city storm drain, complete with piping to emulate water and sewer lines. Customers operate in a confined-space environment with alcoves and several points of entry/egress. The lighting system can be turned on or off and the thick concrete vault cuts off command and control communications, leaving operators to their own devices. The tunnel can be used for rogue laboratory scenarios, operational TTP development and verification, confined space training, or man down/extraction exercises.

Laboratory training exercise inside Avery Tunnel

V-Grid Facility is situated approximately 23 miles west of the Ditto area, is a complex with capabilities similar to Mustang Village, which is authorized for full use of CB simulants, plus characterization of HME and IED. V-Grid facility can be set up for CB scenarios or force-on-force training for land warfare units, and features a:

- Two-story building
- Warehouse
- Ranch-style house
- Guard shack
- Remote terrorist encampment
- Remote airfield is located one mile away

V-Grid Facility

Bang Boxes are twin hemisphere-shaped facilities each having a radius of 7.6 m and nominal volume of 1000 m³ and serve as the principle location for the Chemical Energetics Course. The bang boxes are constructed of PVC-coated polyester fabric, anchored to a concrete pad, and kept rigid by a low-pressure blower injecting fresh air.

Bang Boxes

The facility may be used for material synthesis and testing, plus characterization of explosive munitions. The Bang Box accommodates explosive materials including: hexamethylene triperoxide diamine (HMTD), triacetone triperoxide, peroxyacetone (TATP), deoxyadenosine diphosphate (DADP), cyclotrimethylenetrinitramine (RDX), and ammonium nitrate/fuel oil (ANFO).

Improved Explosive Device/Improvised Dissemination Device (IED/IDD) Lab is used to manufacture IED/IDDs to meet customer requirements. The lab is used for EOD technicians and allows the construction of conventional CB explosive devices, as well as infrared, motion sensitive, and remote detonation devices.

Biological Laboratory Trailer – A 50-foot mobile laboratory that allows for forensic-level detection of biological materials, with polymerase chain reaction (PCR) equipment for DNA extraction and amplification, and on-site sample analysis of biological agents. The custom-built trailer has four slide-out sections creating 940 square feet of work space, including biological safety cabinets (BSL-2) and real-time polymerase chain reaction (PCR) analytical tools. The trailer also contains a waste water treatment system, automated HVAC/pressure system, a 60 kW diesel generator, administrative office, clean room, and a collapsible “mud room.”

Biological Laboratory Trailer

Interior of the biological trailer lab

TTP Development Programs

Dugway TTP development programs and courses combine classroom instruction, laboratory activities, and field exercises that can be tailored to an organization's objectives.   Field scenarios provide realistic opportunities for customers by using role players (acting as civilian responders, victims, and terrorists) and disseminated chemical-biological simulants, reinforcing a customer's confidence to work with CB agents, hazardous materials, and in various threat situations.

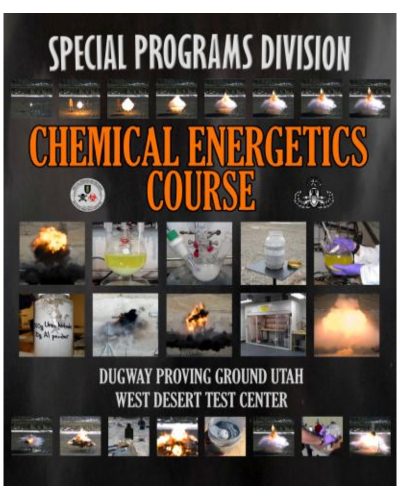
SPD provides many of the nation's protectors with state-of-the-art advanced chemical, biological, and homemade explosives counterterrorism courses. This includes the Advanced Chemical and Biological Integrated Response Course (ACBIRC) for first responders (certified hazardous materials technicians).

ACBIRC training at Mustang Village

The following is a brief summary of selected WDTC courses available on-site or which may be adapted to meet a customer's needs:

Advanced Chemical and Biological Integrated Response Course (ACBIRC) – A DHS-sponsored program for civilian first responders that provides hands-on problem-solving opportunities in chemical and biological (CB) incident response. Instructors conduct lectures and practical exercises in CB environments, focusing on agent characteristics, signatures, sampling, protection, detection, and decontamination. Students work in a BSL-2 lab with live biological agents (vaccine grade), and in certified chemical facilities with chemical agents. Biological and chemical simulants that alarm detector systems are used to enhance practical exercises for real-time evaluation. The five-day course culminates with teams of students in Level-A hazmat suits utilizing their detection, sampling, and analytical skills to respond to CB threat scenarios set in variety of simulated clandestine environments.

Chemical Energetics Course (CEC) – The CEC is designed for DoD explosives ordnance personnel covering the synthesis of chemical energetic materials commonly used in asymmetric warfare, and includes handling, detection, simple characterization of materials, testing, and mitigation. Instructors discuss the types of chemicals that react with one another and how that reaction causes an explosion; class material also addresses issues of sensitivity among explosives and how energetic materials become unstable and reactive. The 40-hour course provides laboratory exercises to characterize energetic materials such as: hexamethylenetriperoxidediamine (HMTD), triacetonetriperoxide (TATP), pentaerythritol tetranitrate (PETN), cyclotrimethylenetrinitramine (RDX), ammonium nitrate (AN), ammonium chlorate (AC), urea nitrate (UN), nitrourea (NU), and 1,3,5-Trinitroso-1,3,5-Triazinane (TT). Instructors also demonstrate a variety of incendiary devices.

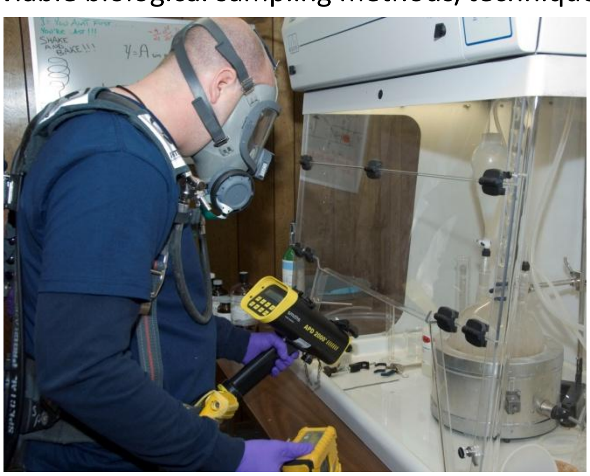


Chemical/Biological Level 1 – A four-day program that includes classroom and laboratory work for chemical and biological agents. The chemical course covers: chemical agent overview, recognition of CWA production methods, chemical agent detectors (classroom and lab), CWA precursors, toxic industrial chemicals (TIC), chemical decontamination and neutralization (classroom and lab), chemical synthesis, and laboratory after action-reviews. The biological course includes: fundamentals of microbiology, biological agent overview, sampling, hand-held assays, biological production, an electron microscope, and exercises in a BSL-2 laboratory. This course is designed for students with an intermediate level of CB knowledge.

Chemical/Biological Level 2 – An advanced-level CB course that includes two days of chemical and two days of biological instruction. The chemical course features: a classified discussion of chemicals, methodologies, threats, and films; an advanced chemical agent overview; higher-level instruction on agent detectors and chemical synthesis; chemical incompatibilities; lab exercises utilizing the INFICON Hapsite® chemical identification system (GC/MS); and related CWA topics. The course includes practical exercises on energetic material synthesis, explosives recognition, and IED threats. Biological instruction covers: aerosol dissemination, sampling kit exercises, "clean man/dirty man" team exercises and agar plate review, sample integrity, a team down-range sampling exercise, and training in analytical equipment.

CWA/BWA Lab Production Course – Customers receive one day each of chemical production and biological production lectures and practical exercises, plus two days of field exercises. Field exercises focus on downrange processes and signature identification.

Biological Sampling and Detection – A course designed to provide customers with an understanding of viable biological sampling methods/techniques and to provide an overview of available detection technology. Course content includes biological sampling techniques and protocols, aerosol sampling, field- and laboratory-based detection platforms and detection methodology.



Advanced Chemical/Biological Warfare Overview – This course is presented to technicians from various Navy Explosive Ordinance Disposal (EOD) units. Course content includes two days of advanced biological instruction, two days of advanced chemical instruction, and one day of threat and intelligence briefings from staff of the National Ground Intelligence Center (NGIC).

Mobile Team Training – Designed to conduct field exercises at a unit's home station, exercises include labs in various stages of production or post-dispersion scenarios. The program includes a hazardous materials training day for local first responders, chemical/biological overview, knowledge of characteristics and production, recognition of equipment, collection/sampling, and decontamination.

Additional Modules – The following is a partial listing of modules available through the WDTC (Note: Attendance in some classes requires a Secret-level clearance):

- Toxic Industrial Chemicals
- Hapsite® Brief and Laboratory
- Hand-Held Assay Brief
- Emerging Biological Threats
- Field-Based Polymerase Chain Reaction (PCR) Course
- Biological Weapon Production Course – Terrorist Scale
- Virus/Cell Culture Course
- Peroxide Explosives Overview
- Improvised Explosive/Improvised Dispersal Device(s)
- Chemical or Biological Material Downrange Response
- Confined Space Hazardous, Chemical/Biological and/or Explosive Material Operations
- Dynamic Breaching (GWOT) Operations

Mobile team training

Chemical, biological, and energetics courses are typically comprised of individual modules that cover:

- Course Overview
- Precursors
- Signatures
- Detection (includes sampling for biological courses)
- Decontamination and neutralization
- Personal Protective Equipment
- Laboratory exercise
- Practical field exercise

Section 10

Modeling

Simulation

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Modeling and Simulation

Division: *Data Sciences* **Branch:** *Test Design and Analysis, Systems Architecture*

Modeling and Simulation Overview

Scientists at the West Desert Test Center (WDTC) develop, validate, and implement modeling and simulation (M&S) at appropriate levels of fidelity to support chemical-biological (CB) and other test programs. M&S applications include pre-test analysis, post-test data fusion, and analysis to support evaluation of untestable scenarios. The capability also supports three-dimensional visualization of results. Some models are high-fidelity, physics-based models, while others are performance-based or empirical models.

Dugway Proving Ground (DPG) supports and conducts live, virtual, and constructive (LVC) testing, and is a node in the Joint Mission Environment Test Capability (JMETC) network through the Distributed Test Control Center (DTCC) (see **Distributed Test Control Center** for additional information).

Modeling and simulation capabilities include the following:

CB Synthetic Natural Environment provides realistic digital representations of chemical, biological, and radiological threats in traditional and urban battlefield environments, and is part of the Chemical-Biological Simulation Suite (CBSS).

High-fidelity, physics-based models give scientists the opportunity to evaluate the performance of CB defense equipment and systems that is not possible due to impractical test conditions, the high costs of certain field trials, limitations on the use of chemical or biological agents, or the ability to portray relevant battlespace environments realistically.

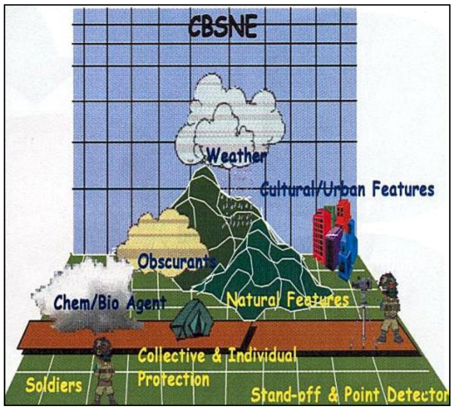
The Dugway Developmental Detector Testbed (D3TB) model supplements field and chamber testing to assess contamination avoidance equipment performance during a CB attack, while the Advanced Chemical Release Evaluation System (ACRES) model assimilates ground truth data from multiple sensors to measure the physical characteristics of simulant releases, providing more accurate data for detector evaluations. The Dugway Collective Protection (ColPro) Model supports testing of ColPro platforms by allowing the user to create test scenarios by specifying terrain, meteorological conditions, and indoor/outdoor transport and dispersion models.

Distributed Test Programs use the JMETC infrastructure to connect with joint service, industry, and academia assets over great distances to leverage the capabilities of others for testing, training, or research. DPG provides access to meteorological data through WeatherServer (WXS) to other participants throughout JMETC to support distributed events.

The DTCC provides test visualization support through the display of live test events via video feeds on big-screen and plasma monitors. Simulated terrain with test assets and/or model outputs can also be displayed. The DTCC also includes the hardware platforms that support M&S efforts.

Chemical-Biological Simulation Suite

The Chemical-Biological Simulation Suite (CBSS) is a set of distributed simulation software tools designed to represent all aspects of CB defense on the tactical battlefield, including applications to analyze strategies, and to provide cost-effective test programs and training of U.S. and allied soldiers. The CBSS is used to:



- Develop effective CB defense materiel
- Evaluate tactics, techniques, and procedures (TTP)
- Provide constructive testing over a wide range of terrain, weather, and delivery conditions
- Provide broad scenario-based training
- Support live sensor testing at Dugway

Chemical/Biological Synthetic Natural Environment (CBSNE) is a component of CBSS provides CB hazard representations for distributed test programs. CBSNE creates high-fidelity, three dimensional (3-D) hazard environments as a function of hazard delivery systems, time-varying meteorological conditions, and complex 3-D terrain. The model makes environmental data available to other simulations, including 3-D representations of airborne vapor and aerosol concentrations, and (over two-dimensional grids) dosage, deposition, and air concentration contours.

CBSNE utilizes either the Naval Surface Warfare Center's Vapor, Liquid, and Solid Tracking (VLSTRACK) model, or the Defense Threat Reduction Agency's (DTRA) Second-order Closure Integrated Puff (SCIPUFF) model, for the simulated transport and dispersion (T&D) of chemical/biological vapors or aerosols. The Winds Over Critical Streamlined Surfaces (WOCSS) consistent-mass/flow model provides high-resolution, 3-D wind field data to VLSTRACK. The Compact Terrain Database (CTDB) delivers a common representation of complex terrain based on National Geospatial-Intelligence Agency (NGA) data.

Chemical Biological Dial-A-Sensor™ (DAS) is another CBSS component that uses modular architecture to recreate the performance of a chemical or biological detector as would be demonstrated under live testing. DAS represents variable-fidelity CB detectors in standalone or distributed simulations and exercises. Users may specify (dial) the physical and simulation characteristics of a detector system based on the parameters of its technology family's characteristics. "Families" of sensors represented within CBSS include: point chemical detectors, standoff passive chemical detectors, standoff active/imaging chemical detectors, point particle-counting biological sensors, and ground-sampling chemical sensors.

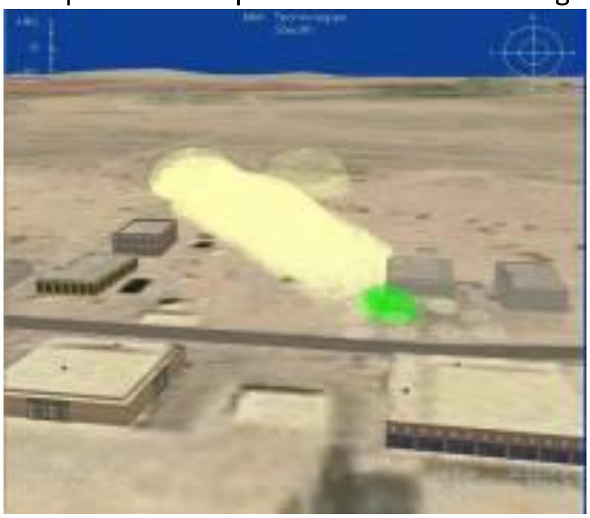
Dial-A-Sensor™ image

A taxonomic structure guides the user through the definition of a detector system across several levels of fidelity within three areas:

- Sensor and simulation attributes
- Sensor ground truth outputs and measures
- Sensor perceived outputs (i.e., alarms, messages, user interface drivers)

Simulated hazards are interpreted by puff table and ground table modules that produce ground truth data of the hazard concentration "perceived" by the sensors. The modules provide the sensors with instantaneous concentrations (mg/m^3), concentration pathlength (mg/m^2), or point concentration arrays (active/imaging sensors) for the vapor and aerosol portions of the hazard. Data is transmitted to the Sensor Performance Module, which is unique for each family of detectors, where the hazard is "sensed" and an alarm or message is generated.

A Non-Real Time (NRT) version of the CBSS provides a new level of functionality for DAS (DAS-NRT) and the Nuclear, Chemical, Biological, Radiological Hazard Generator (NCBR-HG). The NRT version provides customers with variable, user-defined, high-level resolution outputs. Additionally, through the incorporation of optimized sensor modeling algorithms, moderate resolution outputs can be generated in faster than real time should the need arise for executing accelerated simulations.



Continuous representation of dynamic CB hazards over complex terrain

Dugway Smoke/Obscurant Model (DSOM) generates an obscurant representation for distributed simulation with two components to the DSOM architecture: 1) T&D of the obscurant, and 2) determination of the effects of the obscurant. Distributed simulation-compliant T&D capabilities are provided by the DTRA SCIPUFF to calculate a high-fidelity, 3-D obscurant environment, serving as the core simulation for smoke and obscurant transport under time-varying meteorological conditions and over complex 3-D terrain.

The effects portion of DSOM uses the CB Dial-A-Sensor™ tool to simulate degradation of a chemical standoff sensor's ability to perform in an obscurant-degraded environment. The simulated obscurant is interpreted by an obscurant table module to provide sensors with an obscurant concentration length which is convolved with ground truth data to determine a perceived concentration length, which the detector senses in the same manner as for obscurant-free ground truth data.

Exposure Toxicity Server (ETS) is part of the CBSS toolkit and is used to track entity exposure levels during simulation exercises. ETS monitors each battlefield entity's concentration and dosage level and provides the user with these data values at a pre-defined temporal scale.

Additional Modeling and Simulation Programs

Vapor, Liquid, and Solid Tracking (VLSTRACK) is a T&D model that uses two different instances to support field testing and test support programs. One VLSTRACK instance is embedded within the Nuclear, Chemical, Biological, and Radiological Environment Server (NCBR ES). NCBR-VLSTRACK is incorporated into the CBSS and allows the T&D model predictions to be available to the other CBSS tools. The second standalone instance (Standalone-VLSTRACK) is a Windows-based, government off-the-shelf (GOTS) application. Both instances are used extensively to predict hazard propagation routes and downrange concentration/dosage profiles. The Liver, Virtual, and Constructive (LVC) Test Branch also has a classified version of VLSTRACK that contains data on agents not available in the unclassified version.

Hazard Prediction and Assessment Capability (HPAC) is a validated threat modeling program that uses the SCIPUFF T&D model. HPAC/SCIPUFF is used to support various field and chamber tests by conducting both pre- and post-test threat simulations. These simulations provide valuable data to the test community indicating probable hazard trajectory, what downrange concentrations to expect, and where to place referee instrumentation. Additionally, HPAC/SCIPUFF simulations can help fill data gaps by modeling tests that cannot be conducted due to costs, schedules, and/or environmental regulations.

Joint Effects Model (JEM) is a threat modeling program based on the HPAC framework and incorporates new user interfaces and analysis tools. JEM applications are similar to HPAC in that some simulation exercises are common to both, with HPAC serving as an internal validation for JEM.

M&S – Preview the Future

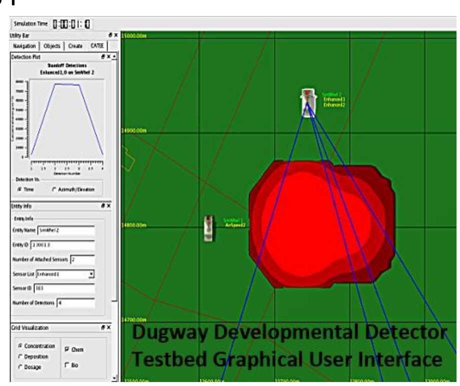
WDTC scientists are conducting a Transport and Dispersion Model Comparison study, a first of its kind, to determine how well different T&D models represent the same threat. Scientists are studying the correlation among five model configurations: the standalone VLSTRACK and HPAC models, JEM, and instantiations of SCIPUFF and VLSTRACK in NCBR. Although previous comparisons between models have been completed, none of them have been as extensive as the current study with respect to varying conditions, agents, and comparison of multiple outputs, and correlations of multiple endpoints. Once the study is complete, customers can be advised to select a T&D model that best meets their requirements based on simulation scenarios and test parameters.

Dugway Collective Protection Model (ColPro) is a toolkit designed to support testing of various collective protection platforms (e.g. shelters, buildings, vehicles). The model enables the user to select from three different outdoor T&D models – the SCIPUFF model, the VLSTRACK model, or the Meso-Scale Realistic Urban Spread and Transport of Intrusive Contaminants (Meso/RUSTIC) model. A fourth model included in the toolkit, the Multizone Airflow and Contaminant Transport Analysis Software (CONTAM), is an indoor airflow and contaminant dispersion model which provides hazard propagation profiles within the ColPro platforms.

The ColPro model allows the user to create a scenario by defining terrain, meteorological conditions, ColPro platforms, outdoor T&D models, and the indoor T&D model. The coupling of both outdoor and indoor T&D models provides the test and evaluation community with the increased ability to make accurate exposure predictions for a variety of threat environments.

Dugway Developmental Detector Testbed (D3TB) is a software tool that provides realistic representations of chemical and biological (CB) threats for assessing point and standoff detection systems in a constructive test environment. The D3TB model, in conjunction with chamber or field CB detector testing, is a cost-effective method to:

- Provide a comprehensive evaluation of detector performance
- Expand the possible threat scenarios and conditions that may not be practical or even possible with traditional testing
- Generate information that could not be provided through traditional testing



Dugway Developmental Detector Testbed Graphical User Interface

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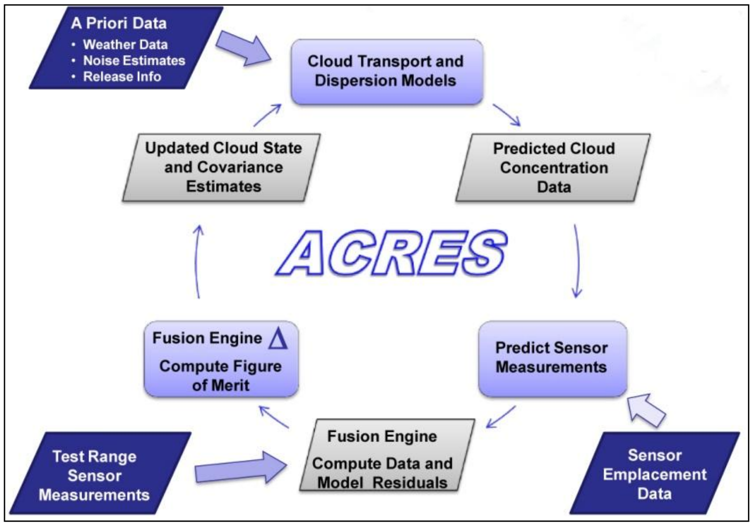
D3TB simulates a wide variety of threat scenarios including threat type (e.g., chemical or biological), delivery method, and transport and dispersion by interface with VLSTRACK, HPAC, and Meso-Rustic models. In addition, D3TB:

- Creates threats from simulated delivery models (e.g., artillery, missile, sprayer, IED) or from fused ground truth instrumentation
- Incorporates physical models for many CB detector classes
- Integrates physical models of various detector platforms
- Includes near-real time or archival meteorological data
- Incorporates real terrain data
- Includes detector logic algorithms for specific program-of-record detectors (e.g., CB point and standoff detectors, such as the Joint Chemical Agent Detector and the Joint Services Lightweight Standoff Chemical Agent Detector)

D3TB operates on a single Linux workstation and is capable of running either single-event or batch scenario processes. D3TB creates statistical measures of total system performance and generates performance reports in a variety of formats to assist testers and evaluators.

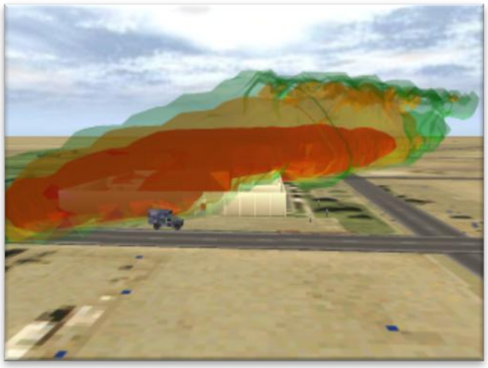
D3TB is a valuable aid for field test planning as candidate detector tests may be simulated prior to actual field tests. By simulating tests first, scientists and engineers can formulate detector performance expectations, facilitating the design of a more efficient test matrix. The simulation can also provide useful data for optimizing sensor placement, utilization of personnel, and safety requirements.



Advanced Chemical Release Evaluation System (ACRES) – A model that reconstructs field test simulant releases, based on ground truth instrumentation output, which assist testers and evaluators in assessing CB detector performance. In the ACRES model, data streams are weighted and fused for the "best" overall physical representation of a field test simulant release.

During a field test, ground truth sensors (e.g., infrared cameras, chemical point sensors, chemical standoff sensors) placed on the test grid measure physical characteristics of simulant releases. These instruments each return a different type of time-dependent data (e.g., dimension, velocity, location, concentration, concentration pathlength) with its own resolution and error characteristics.

ACRES ingests field test ground truth data from a wide variety of sensor types and returns a time-dependent physical representation of a simulant release taking into account the data type, resolution, and inherent error of each individual detector, then weighting each input accordingly. The fused simulant release is either viewed by the ACRES stand-alone 3D viewer, or exported into other T&E M&S tools, such as D3TB or the Dugway Field Test Data Analysis Tool (FTDAT) to allow testers and evaluators to more accurately assess detector performance in the field.



Outdoor dispersion from Dugway ColPro model

Earlier versions of ACRES were developed to approximate simulant releases in the form of a single entity or "cloud," though ACRES has recently been modified to accommodate both multiple-source simultaneous releases as well as individual releases that separate into multiple entities due to natural forces (e.g., weather).

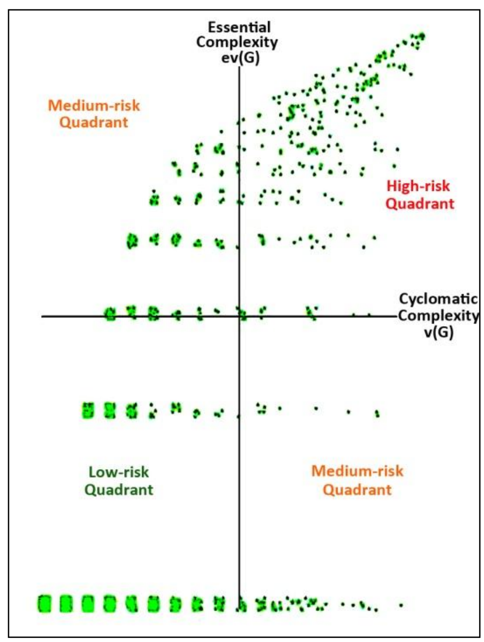
Dugway Field Test Data Analysis Tool (FTDAT) – A software tool used in point and standoff detector post-test analysis that utilizes fused ground truth referee data, including quantitative spatial and concentration information and time-dependent system-under-test (SUT) position, into a more accurate physical portrayal of test conditions. FTDAT analyzes CB cloud data exported from ACRES to determine validity of detection and/or time-dependent exposure levels for a SUT.

FTDAT provides time-dependent concentration (or concentration-pathlength) and ranging information (distance, azimuth, and elevation) from all test SUTs to the ACRES 3-D physical representation of test data, allowing testers and evaluators to more accurately assess detector performance in the field, providing the customer and warfighter with a higher confidence level in the reliability of the detection system.

Developed in collaboration with the Space Dynamics Laboratory (SDL) of Utah State University and Torch Technologies, Inc., FTDAT utilizes existing Robust Adaptive Visualization Environment (RAVEN) visualization applications to provide 3-D displays of detector tests.

FTDAT provides the following time-dependent information:

- Ranging (distance to hazard)
- Hazard location and extents (x, y, z, azimuth, elevation)
- Hazard concentration pathlength (CL) as seen by the detector
- Realistic cloud representations using actual referee data
- Realistic detector field-of-view (FOV)
- Utilization of partial FOV when applicable
- Conical integration through a cloud



Static and Dynamic Software Analysis – The WDTC has added a static and dynamic software analysis capability with the installation of the McCabe IQ Test Team Edition, providing analytical tools for both legacy software and software in development. The addition of this software analysis capability meets a critical need for "software system safety" as described in the Department of Defense (DoD) Joint Software Systems Safety Engineering Handbook.

McCabe IQ Test Team Edition gives DPG a platform-independent (Windows, UNIX, embedded systems) tool capable of analyzing C++, C#, FORTRAN, and Java source code for any target platform. The software allows DPG to add additional computer languages (e.g. Ada, C, Visual Basic, etc.) as required to support future programs.

The tools provide comprehensive code coverage analysis to focus, monitor, and document software testing effectiveness, and help gauge the time and resources needed to ensure a well-tested application. Detailed color-coded graphical displays allow analysts to visualize code and unravel logic, architectures, and designs. Metrics, data elements, changes, tests and parameters are displayed in graphical snapshots of the logic and design of a system's code.

The McCabe IQ Test Team Edition also includes "exclusive comparison technology enabling analysts to unravel exploitable code algorithmic patterns, signatures, similarities, authors, and derivations using widely-adopted industry source code metrics." This security analysis capability will be available during code analysis and testing.

The addition of this software package provides immediate customers, and ultimately, U.S. and allied war fighters, an added level of confidence in Dugway's test programs.

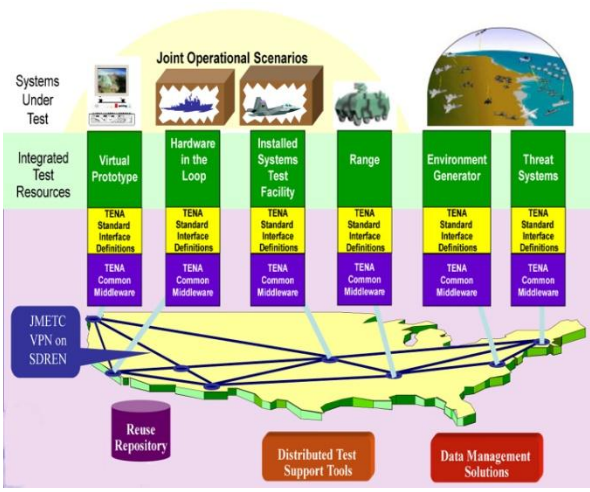
Quick Facts

Use of the McCabe IQ Test Team Edition at DPG has resulted in the discovery of issues with several projects, including one project that made extensive use of deprecated code; a second project was being built in an obsolete environment. Without the software analysis tool, discovery of these issues would have occurred later in the lifecycle at additional expense and delayed delivery, or they could have been delivered with embedded defects, resulting in safety, security, or reliability issues.

Distributed Test Capabilities

Joint Mission Environment Test Capability (JMETC) is a program provides readily available persistent network connectivity to the DoD and to joint services' distributed test capabilities and simulations, as well as for industry test resources. JMETC uses the Secure Defense Research and Engineering Network (SDREN), a network established to support research, development, testing, and engineering (RDT&E) and science and technology (S&T) activities within the DoD.

Dugway was established as a JMETC node in 2010, providing the joint test community with a valuable set of capabilities in the areas of weather data dissemination, chemical/biological modeling and simulation, test control, visualization, monitoring, and data handling.



JMETC links distributed facilities and its customers to efficiently and effectively evaluate warfighting capabilities within a joint context, and provides compatibility between testing, experimentation, and training. As a distributed LVC testing capability, JMETC supports the acquisition community during program development, developmental testing, operational testing, and interoperability certification, including demonstration of Net Ready Key Performance Parameters (NP KPP) requirements in a customer-specific joint mission environment.

In addition to connectivity, JMETC provides common middleware, standard data interfaces, tools, data management, and a reuse repository for collaboration. JMETC is also aligned with and complemented by the Joint National Training Capability (JNTC) to foster test, training, and experimental collaboration.

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TENA WeatherServer (WXS) – The Test and Training Enabling Architecture (TENA) is the middleware of choice for the JMETC. The Dugway weather object models (OM), identified as DPG-Weather and DPG-Atmosphere, have been adopted by the TENA community as the standard.

TENA WeatherServer (WXS) is a data dissemination platform consisting of a high-performance, data-compacting server and a software package. WXS ingests gridded binary (GRIB) files from the Four-Dimensional Weather (4DWX) system (for more information, see **Weather Forecast Systems**), parses the files, and, by utilizing one or both of the OMs, converts the data to a TENA-compliant format, and stores the results. WXS responds to a subscriber's request by retrieving and packaging the data from the requested areas, and then disseminates the data back to the subscriber.

The DPG-Atmosphere OM is an automatic publication of a predetermined set of seven weather parameters (e.g., winds, temperature, pressure, precipitation, clouds, soil saturation, and humidity) that are the most frequent parameters required by subscribers. Every subscriber receives all updates of the seven weather parameters.

The DPG-Weather OM allows subscribers to request data subsets from the selection of 94+ parameters, specifying time, location, and data types; the publisher returns those values to the subscriber. A requested geographical area may be a single point, line, two-dimensional plane, or three-dimensional volume. Combining the two methods allows clients to receive the weather data they require while minimizing the impact of the server's traffic on the network.

Distributed Test Control Center

Division: *Data Sciences* **Branch:** *Test Design and Analysis, Systems Architecture*

The Distributed Test Control Center (DTCC) is a multi-use facility which serves as an integral part of military joint and coalition distributed test capabilities, and local test events. During distributed events, simultaneous test and training activities at various installations are conducted under common operational battlefield scenarios. In local tests, the DTCC is used as a centralized test control point or as an adjunct visualization area.

Teams of test controllers use the DTCC to participate in simulated or live events within Dugway Proving Ground (DPG), in other networked locations, or in a distributed environment, using a system-of-systems approach. Events may include chemical and biological (CB) testing, analysis and modeling, unmanned aircraft system (UAS) tests, meteorology and weather information transmission, data management (e.g., gathering, fusion, dissemination, 3-D visualization, or archiving), test monitoring and control, and sponsoring an observation point for visitors.

Dignitaries and visitors who observe test operations at Dugway may do so in the comfort of the VIP viewing area. The VIP area provides visitors with streaming video/audio from the test site while having access to the West Desert Test Center network, telephones, fax lines, and other facilities. The VIP area provides a safe, cost-effective access to test activities, while centralizing key staff and minimizing the exposure to non-essential personnel.

High-fidelity modeling and simulation (M&S) software is used in pre-event planning, conducting a distributed event, and performing post-event analysis. M&S software provides scenario-based synthetic environments, including physics-based weather forecasts and terrain. The Nuclear, Chemical, Biological, Radiological Environment Server (NCBR ES) provides data for realistic depictions of CB agent dissemination, propagation, and the effects and lethality of agent clouds across the battlefield.

Other live, virtual, and constructive (LVC) data from both local and distributed sources are used by interested participants for various facets of the event. Post-event evaluation is performed by evaluators and program managers to aid acquisition-based decisions in support of today's warfighters.

Data is shared with multiple military installations, contractors, or academia as required over the Secure-Defense Research and Engineering Network (S-DREN), predominantly via the Joint Mission Environment Test Capability (JMETC) node. The DTCC can run other network configurations, including the West Desert Test Center data network, the Army Test and Evaluation Command (ATEC) Test and Integration Network (ATIN), and the Cross Command Collaboration (3CE) network.

A facility expansion project has added a second control center to the DTCC and allows support of simultaneous operations in either classified or unclassified modes across a variety of networks with multiple physical configurations. Each control center is equipped with: seven large-screen monitors (including a new "media wall"), two high-definition (HD) screens, Internet protocol telephones, secure terminal equipment telephones, open storage for classified information, a briefing area certified to Secret level, classified and unclassified data processing, and enhanced security systems. The DTCC also features 40 Windows and Linux workstations with HD monitors.

The DTCC is also a High Performance Computing (HPC) design and development center. Small-scale HPC projects can be designed and run within the DTCC, while larger projects can be designed and then sent to HPC remote locations that have extremely high computational and data storage capabilities.

The DTCC has supported many test programs and entities, such as:

- Heterogeneous Airborne Reconnaissance Team (HART)
- Joint Expeditionary Forces Experiment (JEFX)
- Joint Fighting Information to the Technical Edge (JFITE)
- Army Modeling and Simulation Office (AMSO)
- Joint Expeditionary Collective Protection (JECP)
- Chemical/Biological Defense (CBD) model accreditation
- Multiservice Operational Test and Evaluation (MOT&E)
- Joint Battlespace Dynamic Deconfliction (JBD2)
- Joint Services Lightweight Standoff Chemical Agent Detector (JSLSCAD)
- TENA WeatherServer (WXS)

DTCC – Preview the Future

A future DTCC capability will be an "event playback" feature where events can be viewed in real-time or replayed in order of communications received. The video, audio, and data for each event will be time stamped allowing test officers, customers, and other interested personnel to replay the event at normal, accelerated, or slow speeds.

TOC

U.S. Army Dugway Proving Ground, Utah

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